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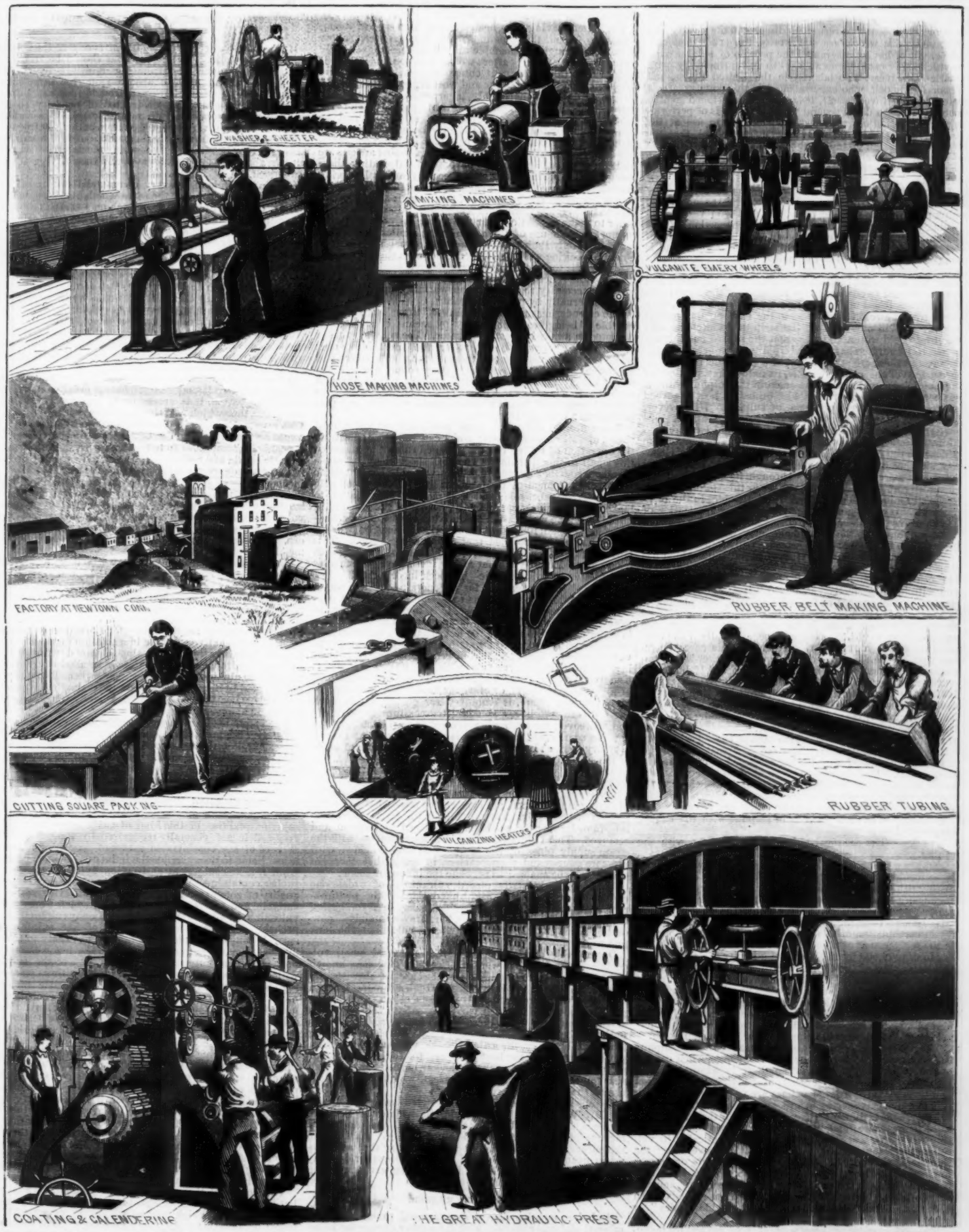


THE MANUFACTURE OF RUBBER AT THE WORKS OF THE NEW YORK BELTING AND PACKING COMPANY.

[Continued from SUPPLEMENT No. 249, page 3962.]

THE INDIA-RUBBER AND GUTTA PERCHA INDUSTRIES.

By THOMAS BOLAS, F.C.S.

LECTURE III.

VULCANIZATION OF INDIA-RUBBER.

ORDINARY rubber, as before stated, retains its most characteristically useful properties through a very limited range of temperature; as a very moderate degree of cold on the one hand, or of heat on the other hand, suffices to render it valueless, as regards the major part of its industrial uses.

At 0° centigrade, caoutchouc is hard and rigid; while, at 100°, it becomes so soft as to become almost valueless as an elastic material. The consequence is that India-rubber, in its natural condition, has a very limited applicability in connection with the industrial arts.

The above-mentioned defects of India-rubber may be, to a most remarkable extent, removed by causing it to unite chemically with a small proportion of sulphur; and, not only does the sulphurized caoutchouc resist the effects of heat or cold, but it also refuses to dissolve in the greater part of those liquids which are solvents of the crude material. The credit of having originated the process of sulphurizing or vulcanizing caoutchouc appears to rest principally with Charles Goodyear, who labored in the United States, and Thomas Hancock, who experimented in this country. In a patent, dated November 21, 1843, the last-mentioned gentleman describes in detail several of those methods of performing the operation of vulcanization, which are in use at the present time; and he distinctly recognizes the fact, that the over-vulcanization of India-rubber leads to the production of a hard, black substance, resembling horn, this substance being now extensively used under the names of ebonite or vulcanite.

Let us now study the effect of sulphur on caoutchouc, by immersing some strips of the substance in baths of melted sulphur. Here, in the first place, is a cast iron vessel, containing sulphur in a fluid state, and an inspection of the thermometer standing therein shows that the temperature of the bath is 120° centigrade. A thin strip of caoutchouc is next partially immersed in the melted sulphur. Now, what is happening? The caoutchouc is absorbing the liquid sulphur, just as it would absorb benzole or coal naphtha; and the caoutchouc swells under the influence of the liquid sulphur, just as it did under the influence of the benzole, only the degree of swelling is far less in the case of the melted sulphur. I will now take out the strip of caoutchouc, and dip it into cold water. You see that the melted sulphur adherent to its surface has cracked up into innumerable fragments, and these are easily removed by a gentle friction on the surface of the rubber. Now, examine that portion of the caoutchouc which was immersed in the sulphur bath; it has become light yellow, and has, probably, now absorbed between ten and fifteen per cent. of sulphur. If, however, it had been allowed to remain in the sulphur bath (at 120° centigrade) for a much longer period, it would have absorbed nearly half its weight of this substance. The caoutchouc which has thus absorbed sulphur differs, as regards elasticity, etc., but little from ordinary caoutchouc, because the sulphur is merely disseminated through its pores, and not chemically united. The India-rubber in this state is subject to the stiffening influence of cold, and dissolves in the ordinary solvents of caoutchouc. By the further application of heat, however, combination or chemical union of a portion of the sulphur with the caoutchouc may be caused to set in, and then the India-rubber becomes truly vulcanized.

Now, then, let me put this strip of caoutchouc, which has already absorbed sulphur, into a bath of glycerine, heated to 140° centigrade; and, if you examine it after the lecture, you will find it perfectly vulcanized. Instead of taking the strip of caoutchouc out of the sulphur bath, and placing it in a vessel of heated glycerine, it might have been allowed to remain for some hours in the sulphur bath, when true vulcanization would have taken place, especially if the temperature had been slightly raised; but, in this case, the result would have been less satisfactory, as an over-large proportion of sulphur would have been absorbed. If, however, one commences the operation with a sulphur bath heated to 135° or 140° centigrade, the vulcanization of a thin sheet of caoutchouc may be completed in a few minutes. Here is a bath of liquid sulphur heated to 138° centigrade; and here is a similar vessel, containing sulphur, maintained at a temperature of 143° centigrade. Into each of these I will place a thin strip of caoutchouc. You see now that both strips are fairly vulcanized after having remained four minutes in the sulphur. Had these strips been allowed to remain for a much longer period in these hot sulphur baths, they would have become over-vulcanized, or converted into a horn-like substance. In these cases the two stages are traceable:

1st stage.—The incorporation of sulphur with the rubber by absorption.

2d stage.—The chemical union of the sulphur with the rubber.

Rubber which contains sulphur incorporated with it may be conveniently referred to as "mixed rubber," in order to distinguish it from vulcanized rubber, or rubber which has chemically reacted or combined with sulphur. It is, at present, a matter of uncertainty whether the change which takes place on heating the "mixed rubber" consists in the direct combination of this element with the caoutchouc, or in the replacement of a portion of that hydrogen which exists in caoutchouc by an equivalent quantity of sulphur; but this latter view of the case is confirmed by the fact that a trace of sulphureted hydrogen is always evolved during the mutual reaction of sulphur and caoutchouc. It is, however, certain that the proportion of sulphur actually concerned in working the change called vulcanization is extremely minute; although it is necessary, in most cases, for a considerable excess of sulphur to be present during vulcanization.

The process of vulcanization by means of the sulphur bath is one which offers many inconveniences, when carried out on an industrial scale, although it is admirable as a laboratory process, or as a means of studying the operation of vulcanization. If large articles are to be operated upon, it is by no means easy to insure an equable action of the sulphur, as it is difficult to keep all parts of the bath at the same temperature; and, when some portions of an article are thin while others are thick, it is scarcely practicable to vulcanize the thick parts all through without overdoing the thinner portions of the article. Again, weights or frames must generally be provided, in order to keep the India-rubber fairly beneath the surface of the melted sulphur, and any trace of solvent remaining in the joints of the goods often becomes volatilized in the bath, causing "blow-holes" or other defects.

These circumstances have made it more general for manufacturers to incorporate the sulphur with caoutchouc by mechanical means, and then to fabricate the "mixed rubber" into the required forms; after which, vulcanization is brought about by exposing the articles to the required temperature. This mode of procedure affords an opportunity for the admixture of mineral or other matters with the caoutchouc, such additions being often necessary, either to color the material or to give it that hardness which is occasionally required; while it is often advisable to replace the sulphur, either partially or entirely, by certain metallic sulphides, such as vermilion or the orange sulphide of antimony; but these sulphides have scarcely any vulcanizing action, unless they contain some free sulphur.

The apparatus employed for incorporating sulphur with the caoutchouc consists of a pair of rollers, which somewhat resemble the washing rollers, only they are plain on the face, and revolve at unequal speeds—three to one being a usual difference between their rates. [The mixing machine and nearly all the principal mechanism used in the manufacture of rubber, are shown in the large engraving on the first page herewith. These views represent the latest and best rubber machinery in use, pertaining as they do to one of the largest rubber factories in the world.]

The rollers having been heated inside, by means of steam, a charge of about thirty pounds of the washed sheet rubber is worked through the machine until it has become tolerably softened and plastic; after which powdered sulphur is sprinkled on the rubber as it enters between the rolls; and this sprinkling on of sulphur and working is continued until all the material is thoroughly incorporated. In ordinary cases, three pounds of sulphur to a thirty pound batch is the proportion employed, and the soft, mixed rubber may be further manipulated at once, or it may be stored away for future use. In most cases, the next step is to roll the material into sheets, as the major part of India-rubber articles are built up of these; and, for the purpose of fabricating these sheets, a large rolling machine (see coating and calendering machine first page), called a calender, is employed; but, before being rolled out by means of this machine, it is necessary to thoroughly warm and knead the mixed rubber, in order to make it plastic. For this latter purpose warming rollers are made use of, these being very similar to the mixing rollers, only they run at nearly an equal speed. The object of making a slight difference between the rates of the two rollers is to give the softened rubber a tendency to remain on one roller (that which revolves most slowly). It is scarcely necessary to say that the warming up rollers are heated internally by means of steam.

The calendering machine consists of three large rollers, capable of being heated internally by means of steam, and mounted in a massive cast iron frame. The softened rubber is first passed between the top roller and the middle one; while the sheet thus formed adheres to the middle roller, and is brought between this and the bottom roller, where it becomes loosely attached to a cloth, which passes through with it. In some cases, a calendering machine with four rollers is employed, but it is questionable whether any proportionate advantage is gained.

There are, on the table, some specimens of calendered sheets of various thicknesses; and I can very well illustrate the operation of rolling out the softened rubber by means of this small rolling machine. The soft sheets may be made to adhere together by merely bringing them in contact while warm, or by cementing them with a little of the mixed rubber dissolved in benzole; and it is a very easy matter to make even extremely complex articles out of the material in question, as the mastication and mixing have so far detracted from its elasticity and toughness that it may be worked almost like putty, provided that it is gently heated. This latter circumstance is more especially true of rubber, with which a considerable amount of any inert powder—such as clay, plaster, or oxide of zinc—has been incorporated.

Although the rubber is so far degenerated by the masticating and mixing processes as to become plastic, and capable of being moulded with ease, it is merely necessary to expose it to a heat of 135° centigrade for two or three hours in order not only to restore the lost elasticity, but to give it the enormously increased strength and elastic power due to vulcanization. The operation of heating the mixed rubber, in order to induce its reaction with the mixed sulphur, is usually called "curing" the rubber. In most cases the heat of high pressure steam, or of water under the influence of high pressure steam, is employed for curing, as, in such cases, it is easy to insure an equal temperature throughout; and, moreover, the rubber is protected from the action of the air. In some cases, however, it is more convenient to employ dry heat, as I shall explain to you in speaking of some of the special applications of India-rubber.

THE VULCANIZING HEATERS.

The steam vessels, or vulcanizers, in which the operation of curing is performed, are constructed somewhat after the fashion of boilers, but are provided with large removable lids, in order that the goods may be placed in position and removed. These vulcanizers are in communication with the steam supply pipes of the works, and are provided with pressure gauges and thermometers, in order that those in charge may be enabled to regulate the inflow of steam.

The long, horizontally placed vulcanizer—of which one end is shown towards the right hand side of the picture—represents the kind of vulcanizer ordinarily used for curing tubes, these tubes being laid in a long tray containing powdered French chalk. [See engraving of vulcanizing heaters, first page.]

On the table, and round about it, are several small vulcanizers, suited for experimental work. This one, known as Child's, and manufactured for the use of dentists, by Messrs. Ash & Co., of Broad street, Golden square, being a very convenient apparatus. It consists of an iron boiler, provided with a lid, which carries a safety valve and an arrangement by which a thermometer can be so placed as to indicate the internal temperature. A little water being placed in the boiler, the articles to be vulcanized are supported over it, and the heat necessary for the generation of steam is produced by means of the gas burner. Messrs. Ash also construct still smaller vulcanizers, which are suited for use on the table of an ordinary room.

Here is a very ingeniously constructed apparatus, made by Mr. Walker, of Birmingham, in which the pressure gauge is so connected with the gas supply, that an undue increase of pressure reduces the amount of gas admitted to the burner; but it is scarcely necessary to say that an automatic arrangement of this kind does not altogether do away with the need of some kind of intelligent supervision during the use of the vulcanizer.

MIXERS FOR RUBBER.

As before mentioned, it is a very usual practice to mix mineral and other matters with the rubber during the incorporation of the sulphur, and it sometimes happens that as much as eighty per cent. of foreign matter is mixed with the rubber in this way. The presence of a large proportion of inert matter naturally detracts from the elasticity of both the mixed and the cured rubber, the former working almost like soft dough in the calendering machine, and this at a comparatively low temperature; while the cured rubber is hard, and comparatively inelastic. The presence of a considerable proportion of inert matter generally diminishes the length of time required for curing.

The powders most extensively employed for thus lowering the quality of rubber are the following: Clay, chalk or whiting, French chalk or talc, barium sulphate, plaster of Paris, oxide of zinc, sulphide of zinc, sulphate of lead, various oxides of lead, oxycarbonate of lead or white lead, magnesia, silica, and fuller's earth.

Some of the above-mentioned materials, specially prepared for the rubber manufacture, are shown in the collection of India-rubber chemicals kindly lent to me by Messrs. Forster and Gregory, of Streatham; and these manufacturers also exhibit some qualities of sulphur specially purified for use in the vulcanization of caoutchouc.

EFFECTS OF SULPHUR AND OTHER CHEMICALS UPON RUBBER.

It is a matter of considerable importance that the sulphur employed for mixing with caoutchouc should be free from all trace of acid, and also from the moisture which acid samples of sulphur tend to absorb from the atmosphere. Ordinary flowers of sulphur—prepared by passing sulphur vapor into large chambers constructed of masonry, so that this vapor shall condense into minute crystals resembling snow—is almost invariably acid in its reaction, as traces of sulphuric acid are formed by the oxidation of the sulphur. This acid may be removed by washing the flowers of sulphur with an abundant supply of water, and then drying it at a gentle heat.

Here is a sample of ordinary commercial flowers of sulphur, and here is some of the same which has been washed and dried. I will put a little of each on a sheet of blue litmus paper, and then moisten them with alcohol. You see that where the unwashed sulphur was placed, the color of the litmus paper is changed to red, owing to the action of the acid, while the color of the litmus paper has not been in any way altered by the washed sulphur. All samples of sulphur ought to be tested in this way before being employed for mixing with India-rubber. Powdered roll sulphur is very often made use of, and it has not so much tendency to be acid as is the case with flowers of sulphur.

The so-called milk of sulphur—or precipitated sulphur—exists in a very fine state of division, and, as far as this circumstance is concerned, it is especially adapted for mixing with India-rubber; but, on the other hand, it is expensive, and is liable to be damp.

All excess of sulphur in vulcanized rubber beyond that actually required is undesirable; but, in order to insure perfect vulcanization, it is necessary to employ considerably more than that which actually combines with the rubber. This excess sometimes effloresces out on the surface, becomes acid, and leads to the destruction of the rubber. It appears also sometimes so to combine with the rubber as to make it brittle and useless. In the case of articles presenting no great degree of thickness, the greater part of this injurious excess of sulphur may be removed, either by boiling them in a dilute solution of caustic soda, or by means of a solution of sodium sulphite. Another method of producing vulcanized rubber, which shall be free from any great excess of sulphur, consists in replacing a considerable proportion of the sulphur originally mixed with the caoutchouc by a metallic sulphide.

The sulphide of antimony is that which is most extensively employed at the present time, the use of this having been claimed by Charles Hancock in a patent dated January 12, 1846; while, in a patent dated February 10, 1847, he fully recognizes the fact that free sulphur ought to be employed in conjunction with the sulphide of antimony. Sulphide of antimony for the rubber manufacture is prepared by boiling the native sulphide in a solution of caustic soda, and precipitating the solution thus obtained with a slight excess of hydrochloric acid. Here is an alkaline solution of the native sulphide, and you see that when I add hydrochloric acid to it, an abundant orange precipitate is produced. This, when washed and dried, is ready for mixing with the caoutchouc.

The sulphide of antimony thus prepared contains, under ordinary circumstances, a certain proportion of free sulphur; but, in order to obtain the best result with the sulphide of antimony, it should contain as much as twenty or twenty-five per cent. of sulphur in an uncombined state. This can be insured by adding the requisite proportion of sulphur to the caustic soda in which the original native sulphide is dissolved. The well-known red rubber is vulcanized by means of the sulphide of antimony, and the superior qualities of this kind of rubber over the ordinary gray article are generally recognized by the public. The absence of any considerable excess of free sulphur renders it less liable to decay under the influence of time and light, while it is less subject to destruction by fatty matters than rubber containing an enormous excess of free sulphur. The quality of commercial red rubber is, however, somewhat variable, and I have met with samples which were scarcely vulcanized at all, the sulphide of antimony employed being probably deficient as to the amount of free sulphur present. When the sulphide contains from twenty to twenty-five per cent. of sulphur, it is generally not necessary to mix more than fifteen to twenty per cent. of the sulphide with the rubber; but when a sulphide of antimony containing less free sulphur is employed, it is possible to add a much larger proportion to the rubber with advantage. No manufacturer should ever employ a sample of precipitated sulphide of antimony without first ascertaining that it contains a proportion of free sulphur suited to his work. Extra sulphur may be added in the form of milk of sulphur, but this proceeding is not so satisfactory as taking the right thing to start with. Other sulphides, such as lead sulphide, mercuric sulphide, or zinc sulphide, are occasionally employed as vulcanizing agents; but, in order that they may act in the most satisfactory manner, it is necessary for some free sulphur to be present; and the amount of this free sulphur should always be exactly known, in order that the vulcanizing may be a matter of certainty, rather than the result of a kind of haphazard guess work. Sulphide of mercury or vermilion intended for use as a vulcanizing agent ought, in most cases, to contain as much as one-third of its weight of free sulphur.

The action of these sulphides is peculiar. They have but little vulcanizing action themselves, but they enable the free sulphur which may be present to exercise its full force; or, in other words, they take the place of that large excess of sulphur which remains ununited with the rubber

in ordinary cases. Well, then, the use of these sulphides renders it possible to avoid the presence of a large excess of ununited sulphur in the finished goods.

Some of the sulphides exercise by themselves a powerful vulcanizing action; and among these may be mentioned the polysulphides of the alkalies and of the alkaline earths, as articles made of thin cut sheet may be very perfectly vulcanized by Gérard's process, which consists in exposing them to the action of a solution of the mixed polysulphides of calcium at a temperature of about 140° Centigrade.

Among Messrs. Forster & Gregory's specimens are many sulphides adapted for use as vulcanizing agents, and others which are merely intended for use as coloring materials, these latter being, probably, free from any excess of sulphur. The fact of Messrs. Forster & Gregory being so well acquainted with the requirements of the rubber trade enables them to prepare sulphides suited for each particular kind of work. Among their specimens may be noticed the antimony vermilion, a very fine coloring matter, but not a vulcanizing agent; the golden sulphide of antimony, which is specially prepared as a vulcanizer, and is manufactured in such a way as to insure uniformity of composition, this being a matter of the greatest importance. Again, we have here yellow orpiment, a bright yellow coloring matter, which may be added to the rubber in any quantity, as it does not vulcanize to any appreciable extent; lead hydrosulphide, a curing agent employed in the making of single texture goods; zinc sulphide, a white coloring matter, which may be added to the extent of forty per cent. to the rubber; zinc oxysulphide, a white coloring material, which is sometimes used in the last coating on spread textures, as it possesses the property of absorbing sulphur, and so prevents sulphuring up, or an efflorescence of sulphur from the more highly sulphureted layers beneath.

When articles made of thin rubber—let us say cut sheet—are embedded in powdered sulphur, and exposed to a temperature of about 112° Centigrade for some considerable time, as much as ten per cent. of sulphur is absorbed by the caoutchouc, and this absorption is facilitated by rubbing the powdered sulphur on the surface of the caoutchouc. This method of sulphuring cut sheets, and articles made from cut sheets, is of considerable practical utility in many cases, and the goods so charged with sulphur may be cured in the ordinary steam vulcanizer.

COLD CURING PROCESS.

Parkes' cold curing process, briefly referred to in a previous lecture, is one of the neatest things existing in the whole rubber trade. Here is a piece of cut sheet rubber, which I now dip for an instant in a mixture of one part of chloride of sulphur and forty parts of carbon disulphide; after which I lay it for a minute on a tray covered with French chalk and heated to about 40° Centigrade. The portion which was dipped is now vulcanized; perhaps not all the way through, but very nearly. This method receives numerous applications, especially for the vulcanization of articles made from cut sheet rubber. In this case it is probable that the chlorine removes hydrogen from the rubber, and that the sulphur takes the place of the removed hydrogen. A study of the process in question shows us how very minute is the proportion of sulphur actually concerned in vulcanization. In Parkes' process we have one of the most perfect vulcanizing processes existing, as combined sulphur alone reacts, and the finished articles are quite free from any trace of sulphur in an uncombined state. An after-treatment with water, or a weak alkaline solution, may be adopted to remove traces of hydrochloric acid. Light petroleum is now often employed in this process instead of carbon disulphide. Some hypo-sulphites, especially the lead salt, are capable of acting as vulcanizing agents, but are not very extensively made use of. Vulcanization by hypo-sulphites is, however, interesting, as affording another instance of combined sulphur acting as a curing agent.

Other reagents besides sulphur exercise a hardening or vulcanizing action on India-rubber; as, for example, nitric acid and the halogens. Warren claims the use of these latter bodies in his patent dated February 26, 1871, and he has very successfully vulcanized the insulating coating of telegraph wire by means of iodine. A piece of cut sheet rubber dipped into bromine becomes vulcanized instantly. Warren's process has been applied in America to the production of vulcanite bases for artificial teeth.

When sulphur and caoutchouc are mixed there is a certain tendency for them to unite slowly, especially if exposed to the rays of the sun, a kind of gradual vulcanization or curing being the result. This is very well exemplified in the case of the cork hat or helmets, manufactured by Messrs. Hawkes & Co., of Piccadilly, to whom I am indebted for this very complete set of specimens illustrative of their manufacture. The segments of cork, out of which these helmets are made, are cemented together by means of a solution of rubber in purified camphine, but a certain proportion of sulphur is added to the solution. During the time that the helmet is in use the India-rubber cementing medium gradually becomes vulcanized, increasing in toughness and hardness by exposure to the heat of the sun. If, on the other hand, no sulphur were present, the rubber would rapidly deteriorate, and the helmet would fall to pieces if used in a tropical climate.

I have to thank several manufacturers for lending me many of the numerous specimens of vulcanized rubber which are before you this evening. Messrs. Macintosh, Hancock, Davis, and Henwood, the Silvertown Company, and others, having been most kind in this matter.

The remarkable power which vulcanized caoutchouc possesses of recovering its shape after compression is well illustrated by the fact that a sphere, two and a half inches in diameter, passes between rollers set to a distance of a quarter of an inch without suffering any permanent injury as regards form.

SUBSTANCES WHICH DISSOLVE AND INJURE RUBBER.

Although vulcanized rubber is insoluble in the ordinary solvents of caoutchouc, boiling oil of turpentine will dissolve it; and sulphide of phenyl, a liquid discovered by Dr. Stenhouse, will soften it so far as to render it reworkable. Old vulcanized rubber, reduced to a state of fine division, can be incorporated with new rubber in many cases, and there are other methods by which waste vulcanized rubber may be utilized, as, for example, in the manufacture of kamptulicon, which will be referred to in the next lecture.

Oils and fats exercise a very destructive action on India-rubber, more especially when the caoutchouc is unvulcanized; and through the kindness of Mr. T. S. Speck, engineer to the London District Railway Company, I am enabled to show you a very interesting specimen illustrative of this. It consists of a piece of one of the caoutchouc pipes employed to lead gas into the trains at the Hammersmith Station, and the pipe from which this specimen has been cut was placed in immediate proximity to the stopping-point of the engines. You see how deeply and thoroughly the pipe is corroded and destroyed by the action of oil from the engines, while the other pipes in the station are in excellent preservation.

Some of the conditions which are favorable to oil-resisting powers, in the case of vulcanized caoutchouc, are as follows:

1. The use of a high quality of rubber.
2. Thorough curing.
3. The absence of free sulphur in the finished article.
4. The presence of such pigments as litharge, red lead, or white lead.
5. The incorporation of a trace of glycerine with the materials.
6. Curing in a glycerine bath. (Placed in an ordinary steam vulcanizer.)

On the table you will see some interesting specimens, kindly lent by Mr. Tuck; these illustrate the matter in question, and you will notice how well Mr. Tuck's special oil-resisting rubber has withstood the action of mineral and other oils.

Ordinary vulcanized rubber gradually deteriorates when maintained at a temperature near 130° Centigrade, becoming brittle and evolving sulphureted hydrogen. This may be principally due to the reaction of the still uncombined sulphur on the caoutchouc. Exposure to the sun's rays will often produce a similar effect on caoutchouc containing free sulphur in considerable excess. Thus we see that, although both heat and exposure to light have a curing action on mixed rubber, the over-long continued action of either agency tends toward mischief.

LECTURE IV.

SPECIAL APPLICATIONS OF VULCANIZED INDIA-RUBBER.

Few materials have received such numerous applications in the industrial arts as vulcanized caoutchouc; and in many instances the applications of India-rubber are of considerable commercial importance. So various, indeed, are the uses to which this material is applied that the mere reading of a list of its applications would occupy much more than the hour allotted for this lecture—as a rough estimate, I should say it would take just about two hours and three-quarters—so I will not do it, but will rather call your attention to a few matters which either are of special interest or happen to present themselves to me to-night.

A pad of India-rubber has a remarkable effect in deadening vibration or recoil, and a slab or sheet about an inch thick is a useful thing to place underneath an anvil in order to reduce the noise arising from hammering thereon. Again, you know that railway carriage buffers work against blocks of caoutchouc, these having a remarkable effect in reducing the destructive action arising from the jarring and striking of the carriages against each other. In the case of rubber intended for such purposes, there is generally no disadvantage in somewhat hardening the material by admixture with either one of the inert powders already referred to as being suitable for lowering the quality of vulcanized rubber.

Here, among the articles lent by the Silvertown Company, is an arrangement for lessening the recoil of an ordinary shoulder gun or rifle. It consists of a plate of ebonite, faced with soft rubber, and is intended to be attached to that part of the gun which is placed next to the shoulder.

MANUFACTURE OF RUBBER THREAD.

The production of threads of caoutchouc by the process of squirting is one of considerable interest, and it can be illustrated to you in a very simple manner. Here is a metal apparatus very similar in size and appearance to a small pewter squirt, and I will fill it with caoutchouc which has been softened by means of a small proportion of benzole. The beak of the apparatus being placed in the focus of the lantern lens, you see that a magnified image is projected on the screen. The piston being now forced into the cylinder, the softened rubber is driven out in the form of a cord or thread, which really descends from the nozzle of the squirt; but, owing to the inverting action of the lens, it appears to ascend on the screen. The threads thus formed must be exposed to the air in order that all traces of benzole may evaporate, after which they may be cured in any of the usual ways.

In the large machine the piston is forced down by gearing, and in the lower part of the cylinder a series of fine wire gauze strainers is fitted, in order to remove any solid impurities which may be present in the caoutchouc paste. The pressure of the piston next forces the India-rubber into a horizontal tube, the lower part of which is perforated by a series of holes, out of which the material exudes, forming a row of threads, these being then led forward by an endless band of velvet. The threads next pass into a trough which contains running water; whence they are afterwards carried by a long endless band of calico or linen, on which they become sufficiently dry to be wound on bobbins, a little French chalk being made use of to prevent adhesion.

Washers and circular valves are largely employed for many purposes, and these may be cut out of the mixed rubber sheet, or they may be moulded out of the mixed rubber. In either case they can be embedded in French chalk during the process of curing by steam, or they may be cured in moulds, brass, tinned inside, being a very general material for these. The merest trace of oil on the surface of the mould prevents any adhesion to it during the curing process. It may be premised that it is generally necessary to support articles of mixed rubber during the process of curing by heat, as the material softens very considerably before the true curing action steps in. Sheets are generally supported by being wound on a drum together with a cloth, and are then cured in water, while many small articles may be conveniently cured in moulds made of baked clay or slate, these being cheaper and more easily made than metal moulds. It often happens that it is more convenient to cut small washers and disks from the vulcanized sheets, although this course naturally involves some waste of material.

The firms which were mentioned at the last lecture have placed at my disposal the extensive series of specimens illustrating the above-mentioned uses of India-rubber, and you can examine these for yourself after the lecture.

RUBBER TUBING.

The manufacture of the various kinds of tubing forms a very important part of the rubber industry. The usual manner of fabricating tubes is to cut the mixed rubber sheet in such a way that, when the edges are put together, no ridge shall be left projecting on the inside or outside of the tube.

A strip of the softened mixed rubber sheet being bent over on itself, the edges are cut off on an incline. On now placing the fresh edges together, they fit together, forming a tube, and a loosely-fitting mandrel being introduced, the joint is strengthened by being rolled longitudinally with a small roller, resembling a miniature garden roller, made slightly hollow in the middle. The mandrel is generally left in during the vulcanization or curing of the tubes, the so-called "chalk cure" being adopted, as already explained. [See engraving, first page, "Rubber Tubing."] Very often the removal of the mandrel presents some difficulty, and, in consequence of this, it is not unusual to employ a spiral wire instead of a solid metal mandrel, this being left in the tube when sold. Machines have been constructed for the making of tubes, but with varying degrees of success. In the case of tube machines, a flexible core, or kind of rope, is generally used as a mandrel. Tubes are often built up of alternate layers of India-rubber and canvas, this latter being saturated or filled in with softened rubber by means of the frictioning machine. The frictioning machine somewhat resembles a calender; indeed, it often happens that the calender is fitted with gearing, to enable it to be used as a frictioning machine; and, in passing between its rollers, the interstices of the canvas becomes so filled with the softened rubber that the frictioned material can be worked in with the rubber when composite tubes are desired. In some cases a spiral wire is embedded between two layers of India-rubber, the tube thus obtained being well adapted for suction purposes. The variety of tubes thus built up out of rubber, wire, and textile materials is very great.

Another method of making tubes is by the squirting process already illustrated to you in the case of threads. In this instance the mixed rubber, previously softened by heat or by a solvent, is forced through a die, but this must be provided with a central core or mandrel, to form the bore of the tube. Seamless tubes made in this way are very useful for laboratory and other purposes. On the table there are some interesting samples exhibited by Mr. Hancock.

The so-called insertion sheet, which is composed of alternate layers of rubber and frictioned canvas, is very useful in case great strength should be required. Sometimes wire gauze is inserted between rubber sheets in a similar manner.

RUBBER PACKING.

India-rubber steam packing is of very great value for making the stuffing boxes of engines steam-tight. It is also employed for packing the shaft holes of vessels, and other similar purposes. The steam packing generally takes the form of a cord, built up of India-rubber, frictioned canvas, and lubricated or stearined cotton. [The method of cutting square packing is shown in the engraving on first page.]

The use of gas bags, air pillows, beds, etc., formed of two thicknesses of cloth separated by a layer of rubber, has now become very general, and one can only appreciate the ingenuity exercised in the manufacture of such articles by either seeing them put together or cutting one of them open, so as to expose the method adopted in building it up. Gas bags have been found very useful for carrying a supply of illuminating gas for the lighting of trains; but the use of them somewhat impoverishes the gas, as the caoutchouc absorbs several of those hydrocarbons which contribute largely toward its illuminating properties. As an insulating material for telegraph and other electrical wires, caoutchouc holds a very high place.

RUBBER BELTS.

Belting, for the transmission of power, can be very advantageously made of alternate layers of rubber and frictioned canvas, these being built up to the required thickness. Belting is generally cured by dry heat, and in the following manner: An iron mould, something like a gutter, is provided, this being planed out to the exact width of the belting. Into this gutter-like mould, which may be about twenty feet long, a strip of iron fits accurately; so that a piece of belting introduced into the mould is inclosed everywhere excepting at the ends. One end of a length of made-up, but not cured, belting being introduced into the iron mould, the necessary heat for curing is applied by means of a massive steam press [see the great hydraulic press and also the rubber belt-making machine in our engraving, first page], which consists of two rectangular cast-iron chests, heated internally by steam. Generally speaking, the chests are heated to a temperature as high as 150° Centigrade, in order that the vulcanization may proceed quickly. In about twenty or thirty minutes a fresh portion of the belting is exposed to heat in the mould, and so on until the whole length has been vulcanized. The method of vulcanizing in question possesses the advantage of yielding belts with very accurately square edges, so that the whole width is available for the transmission of power. The steam press is excellently well adapted for the vulcanization of figured or patterned sheets of caoutchouc, intended for ornamental purposes, and the engraving represents such a use being made of the apparatus. India-rubber belting should, naturally, be protected as far as possible from the action of oil, as the continual motion and straining very much favor the destructive action of fatty matters upon it.

Caoutchouc has been largely employed in the manufacture of surgical appliances, several examples of such uses of caoutchouc being now before you. Elastic stockings, belts, and bandages are of considerable value, as they exercise a more continuous and equal strain than would be the case with ordinary bandages. Messrs. Cow & Co. have provided some samples of their extra-elastic bandages, made out of spread sheet—a form of rubber which will be considered in the course of the evening. Other appliances—such as infants' feeding gear, injection apparatus, pessaries, etc.—are represented in the collection before you, but they require no special explanation.

As regards uses of caoutchouc bearing on every-day life, very much might be said, but the time is, unfortunately, rapidly advancing. The making of an umbrella ring is a very ingenious and curious operation, which I will proceed to illustrate to you. A strip of the softened and mixed sheet rubber is cut off obliquely at each end as you see me now cut it, and after it has been rubbed over with rubber solution to render it adhesive, the obliquely cut ends are brought in contact, so that a short tube is formed. This being next placed on a mandrel, one end of the short tube is turned over on itself continuously, so as to convert the tube into a round-rimmed ring. In practice the operation is conducted much more rapidly than I have done it. The rings are laid in French chalk and cured by a steam heat; but very often these articles, instead of being made of mixed rubber, are manufactured from cut sheet.

The squeegee is an instrument of American origin, and consists of a stoutish strip of vulcanized rubber mounted scraper fashion in a piece of wood. The scraper-like edge of the India-rubber slides with very great ease over any wet

surface, forcing before it any dirt or foreign matter in a manner which is surprisingly complete. No doubt you have all seen the squeegee made use of for cleansing the roads and pavements in rainy weather. The squeegee forms an admirable window cleaner, as I can illustrate to you by applying one to a piece of dirty glass; but it must always be used in conjunction with an abundant supply of water, as the friction between India-rubber and dry glass is very great. Considerable use is made of the squeegee in several of the photo-mechanical printing processes, which I had the pleasure of illustrating to you two years ago, as some of you will doubtless remember.

Door mats of vulcanized rubber are now being extensively made use of. The mixture employed for their manufacture is generally of a very low quality; old vulcanized caoutchouc, fibrous materials, and mineral matters, such as whiting, being freely added; about twenty per cent. of a low quality of new rubber, such as African tongue, being often considered sufficient. The material having been calendered to the requisite thickness, a very partial and imperfect curing is generally effected at this stage, the sheets being exposed to a moderate heat between metal plates, these being often corrugated. After this the patterns of the mats are cut out by means of punches and cutters, the device having been stenciled on the sheet by means of French chalk dusted through a perforated metal plate. The mats are next laid in French chalk and cured by steam. The punchings are worked over again, the slight preliminary curing or setting being insufficient to offer any notable hinderance to this course.

A very excellent method of manufacturing mats, but one not adopted to any great extent in this country, is to mould them in cast-iron moulds, and then to cure by the dry heat of the steam press. Other methods, such as building up the mats out of strips, are also occasionally adopted. Nearly related to door mats are door stops, or buffers, articles of considerable utility in preventing damage to houses by a continual banging of the doors. Small blocks of rubber are often set in the door frames of railway carriages to receive and deaden the first effects of the blow resulting from a rapid shutting of the doors.

RUBBER TOYS.

In the manufacture of toys the applications of caoutchouc are very numerous and often exceedingly ingenious. Here is a small air ball, or balloon, to which is attached a wooden tube, provided with an India-rubber strip, acting as a reed. The reed does not vibrate while the balloon is being distended, and, by closing the tube by means of one finger, the air may be retained in the balloon; but on removing the finger, out it goes with a rush, causing an unearthly screak, calculated to delight the infant mind. Hollow playing balls are made of four segments of calendered sheet, put together balloon fashion. Here is one at this stage; it certainly does not look much like a ball, but more like a withered pear, which has resided for some time in a square tube rather too small for it. The next step is to inclose the incipient ball in a hollow spherical mould, best made of slate, and to expose it to a vulcanizing heat. The air inside the India-rubber now expands, forcing the material into close contact with the mould, and when the vulcanization is complete, a perfect counterpart of the interior of the mould is the result. As the included air contracts, the ball, to some extent, collapses, as you see in the case of these samples; but by cutting a small circular hole in one of the balls, it, as you see, can be made to regain its spherical shape immediately. In some cases it is considered better to tightly distend the cured balls by compressed air; and this may be effected by attaching a small lump of unmixed rubber to the interior of the ball before it is made up, and this lump undergoes no change in the curing process. When the cured ball is taken from the mould a sharp-pointed or sting-like tube is passed through at the point where the lump is situated, and air is forced in through this tube. On withdrawing the tube the hole closes, and the freshly-divided surface of the unvulcanized rubber unites again.

RUBBER SPONGES.

I do not think I told you anything about the so-called India-rubber sponges, or frost-like rubber, which may be used for toilet purposes, as padding, or as rubbers for cleaning shoes or various other articles. It is made by incorporating with the rubber certain substances which will give off vapor or gas during the process of curing. Among these may be mentioned damp sawdust, crystallized alum, and carbonate of ammonia. The sponge is vulcanized in moulds, which it fills during the act of expanding. An ingenious application of the sponge rubber is made in the manufacture of a certain kind of playing ball. Some of the sponge rubber composition, which, by the bye, may be compounded as follows,

20	parts washed rubber of low quality,
10	parts red lead or other pigment,
50	parts old vulcanized rubber in a finely-divided state,
8	parts sulphur,
6	parts damp sawdust finely ground,
6	parts oxidized linseed oil,
100	

is wrapped round a small ball of wood, and the whole is then placed in a spherical mould somewhat larger than the wooden core and its rubber envelope. The heat necessary for curing being now applied, the rubber swells and fills the mould. On taking one of these sponge balls into the hand its softness would naturally cause one to think it was made of a fine quality of rubber, and to wonder at it being sold at the low price charged; but, on cutting it in two, the mystery is explained, a wooden core and a coating of very low quality sponge rubber being its factors. Very many hollow articles are made in moulds in the same manner as the hollow balls; not only toys, such as dolls, being produced in this way, but also such goods as injection bottles and analogous articles; the principle of utilizing the expansive force of air for forcing the rubber up to the sides of the mould being of widespread application in the rubber industry. Tin or cast-iron moulds are often employed, and, in some cases, a compression of air into the finished article is rendered unnecessary by adopting the expedient of forcing air into the article after it is placed in the mould, but before curing; the soft mixed rubber closing immediately on the minute hole, which is necessary for this purpose.

The use of India-rubber for cleaning paper and erasing pencil marks is a well-known application of the material, but its usefulness in this respect can be very much increased by incorporating certain gritty materials with it, such as pumice or finely-divided silica. Messrs. Wolff & Sons exhibit a collection of rubber specially prepared for these uses; and they have adopted the plan of mounting the rubber, squeegee fashion, in wooden blocks. By this arrangement, contact between the hand and the rubber is avoided. Some people let their erasing rubber get very dirty, and then express surprise that it fails to clean paper.

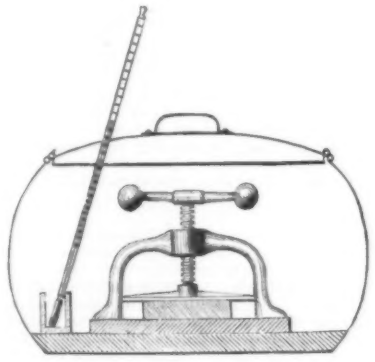
Very pretty casts or mouldings of phototypic reliefs may be made in vulcanized India-rubber; and I will next illustrate to you the method of making such casts, at least as far as the manipulation of the caoutchouc is concerned. Here is an ordinary photographic negative, and this is a type metal cast or mould, produced by photographic agencies from the negative. Those portions of the negative which are opaque correspond to relief in the type metal mould, while the depressions of the mould correspond with the transparent portions of the negative.

The first step is to very slightly oil the mould, after which blacklead is applied to the surface, and the excess is polished off by means of a soft brush. A sheet of mixed rubber, previously softened by heat, is next applied to the prepared surface of the mould, and curing is effected by means of the small hot press into which the mould and rubber are now placed. A hot press of the kind now before you is very convenient for the curing of small flat articles and casts. It consists of a cast-iron fish kettle, upon the bottom of which rests a slab of type metal an inch thick. Inside the kettle is placed a small press, like a copying press in miniature. By the side of the press stands a small iron cup, containing glycerine, and in this fluid is immersed the bulb of a thermometer, the stem of which projects through a hole in the cover of the kettle. By means of a small gas stove, heat can be applied to the apparatus, and it is easy to so adjust the gas supply that the thermometer shall indicate a tolerably constant atmosphere of, say, 140° or 150° Centigrade. Most qualities of mixed rubber will become fairly well cured by being heated under these circumstances for half to one hour, and any tendency toward adhesion to the mould is obviated by the preparation with oil and blacklead, as described.

RUBBER STAMPS AND PRINTING PLATES.

This apparatus is extremely well adapted for curing the India-rubber stereotypes or stamps, which are now so extensively used for indorsement and other purposes. To make these stereotypes, a reverse or mould is made from the types, this being taken in plaster of Paris, or better still, in metal. When plaster is employed it is well to harden it, by saturating it with an alcoholic solution of shellac, and again drying. The soft mixed rubber is then forced into the mould, as you now see me doing it, after which the curing may be effected in the hot press.

Mr. John Leighton introduced rubber stereotypes about eighteen years ago, and since that time their use has become very general for a great variety of purposes. Mr. Leighton has very kindly sent, for your inspection, an interesting collection of specimens, illustrative of the manifold uses to



which India-rubber stereotypes can be applied. Glass and other hard bodies may be printed on with the greatest ease; and, by dusting the impression with a vitrifiable color, the impressions may be burnt in. Here are some of Mr. Leighton's specimens, illustrating what was done in this direction as far back as ten years ago. Again, the rubber stamps lend themselves admirably to the production of impressions on curved or cylindrical bodies; this being illustrated by rocket cases, printed under Mr. Leighton's directions, twelve years since. Much ingenuity is displayed in the construction of the various self-inking pocket and pencil stamps.

I, for one, believe the time will come when newspapers and books will be largely printed from India-rubber stereotypes. They can be easily and rapidly made, and I have cured rubber very successfully in the usual paper or "flong" moulds, faced with tin or lead foil, this latter being laid first on the type. The steam press might be employed for curing a rubber stereotype much larger than anything yet attempted in metal; and, by employing a suitable rubber composition, it is not unlikely that a thorough curing might be effected in as short a time as ten or fifteen minutes. The power required to drive printing machines, working with rubber stereotypes, would be comparatively small, while impressions quite as sharp as those from metal ought to be secured. One advantage of the rubber stereotypes would be the ease with which they can be adapted to cylinders of any curvature. As regards ink for stereotypes, a few words may be said. A fatty ink naturally injures the rubber; at any rate, if it is not very carefully removed after use; but an ink having glycerine as a basis answers extremely well, and may, as the specimens on the table prove, be left in contact with the stamps without in any way injuring them.

Inking rollers made of India-rubber have been occasionally made use of from time to time for many years, but owing to inexperience in their manufacture and use, the results have been, until quite recently, far from satisfactory. You will probably remember that, when lecturing here on photo-mechanical printing, I showed you how a printing roller could be made with a body of the usual soft gelatine composition, and a face of red vulcanized rubber, smoothed by means of glass paper. This circumstance brought to my knowledge the fact that Mr. Robert Lanham had been very successfully laboring in the improvement of India-rubber rollers. By the kindness of Mr. Lanham, I was enabled to show you some of his rollers at the lecture immediately following the occasion when I showed you my own. During the two years which have elapsed since that time, Mr. Lanham has still further developed the manufacture of rubber rollers for printing purposes, and I am indebted to him for the opportunity of now showing you the very fine collection of these articles which stand over yonder. Mr. Lanham makes his rollers from red rubber, which is, of necessity, very thoroughly cured, in order to enable it to withstand the action of fatty inks; and after the rollers have been turned true by means of self-acting lathes, a fine surface is given to the rubber by means of glass paper. In order to give his rollers the softness which is necessary in some cases, Mr. Lanham now introduces a series of perforations parallel to the axis. For lithographic printing, these rollers have very considerable advantage over the usual leather roller, and some excellent samples of work done with them hang on the walls.

India-rubber does many services in connection with the art of printing, some of these being of very great interest, but it is impossible to go farther into the matter this evening.

RUBBER WATERPROOF GOODS.

Waterproof goods, consisting of a thin layer of rubber spread on a textile fabric, are very extensively made use of for the fabrication of overcoats and other waterproof garments. In the manufacture of these goods, the first step is to prepare a dough or paste suitable for spreading on the material. If the vulcanization of the coating is to be effected by means of steam heat, as in the case of cotton or linen goods, a composition of the following nature may be spread on the fabric: Twenty pounds washed rubber, twenty pounds zinc white, five pounds sulphur, six or eight pounds of solvent naphtha. When, on the other hand, the curing is to be performed by the cold process, the sulphur may be omitted. After the rubber has been softened by the absorption of the solvent naphtha the materials are thoroughly incorporated by means of a mixing or kneading machine.

The action of a spreading machine is afforded by the model which is now before you. It consists of a base-board, over which is supported a rule-like bar. The material to be coated is placed under the bar, a quantity of the paste or dough is piled up in front of the bar, and the cloth is drawn forward, so that the rule or bar cuts off an even layer of the soft mixture. In actual practice, the fabric, after having received a coating of the composition, is passed over a heated steam chest in order to dry off the solvent naphtha. In the case of ordinary goods about six coats are given—three in each direction. Each coat may be estimated as being about one-hundredth of an inch in thickness.

The method of applying the mixture of carbon disulphide and chloride of sulphur used for effecting the cold vulanization of the India-rubber coating, when spread on goods which would be injured by high-pressure steam, is of some interest. The coated fabric passes round a roller, coated side being outward, and it is brought into contact with a more rapidly-revolving slate roller, which dips in the vulcanizing solution, this being contained in a trough. The solution, which consists of one part of chloride of sulphur and forty parts of carbon disulphide, is led upward by the roller toward the point, where it forms a kind of accumulation or wave. All excess drains back as the fabric travels.

Double-texture fabrics can be produced by employing similar apparatus, but double; and the two textures, which are vulcanized simultaneously, are brought into contact immediately after the curing solution has acted on them. Under these circumstances they adhere, but when made up into coats, etc., these double textures can be separated at the edges by the application of benzole; this being a matter of great convenience in joining the various parts of a garment together.

Spread goods are often varnished by the application of a dilute ammoniacal solution of shellac, the surface of the goods being generally prepared for the reception of this by the application of water, or of water containing a trace of an alkali, soap, or ox-gall, either of which facilitates the adhesion of lac varnish.

Spread sheets, already referred to several times, are made by spreading a mixture of sulphur (or other vulcanizing material) and softened rubber on clothes previously charged with a mixture of paste, treacle, and glue. The required thickness having been built up, vulcanization is effected by means of steam, and the prepared cloth, being softened by the action of water, can be easily removed from the sheet of rubber. Sometimes the required thickness of spread sheets is built up on two separate pieces of the prepared cloth, and the adhesive surfaces of the rubber being placed in contact, they unite, after which vulcanization is effected in the usual way, and the cloths are removed.

Spread sheets, prepared by the latter method, show the marking of the cloth on both sides, while those prepared by the first method are smooth on one side. As a general rule, spread sheets are more perfectly elastic than calendered sheets, as the rubber undergoes less mechanical tearing or deterioration. They are generally preferred for cutting into threads.

Mr. Sexton, the representative of the National India-rubber Company, of France, has kindly lent me a well-assorted set of specimens, illustrating the use of caoutchouc in the manufacture of boots and overshoes, this firm turning out over two millions of pairs yearly. Articles of this kind are generally made out of a mixed rubber, which is calendered on to woven or knitted fabrics, these having been previously frictioned. After the articles have been made up and varnished they are cured in stoves or ovens, heated from 130° to 150° Centigrade.

Several processes have been proposed for the desulphurization of old vulcanized caoutchouc, but the success attending endeavors of this kind has been very limited. The incorporation of old rubber with new has been referred to already. The use of old rubber in making the admirable floor cloth known as kamptulicon is a very useful application to it.

KAMPTULICON.

Kamptulicon consists of old rubber and cork, both materials being brought in a state of fine division, after which they are incorporated by heated rollers, and then rolled out into sheets. You need not seek far for a specimen of this material, as the floor of this room is covered with it. The Britannia Rubber and Kamptulicon Company have lent me the figured and patterned specimens which are attached to the wall, and also other articles, which illustrate the various uses of this material. Knife-cleaning boards are often covered with it, and, when made up into sheets two inches thick, it is extensively employed as a means of deadening the effects of concussion. These thick sheets are particularly adapted for covering the floors of riding schools, or for lining cells in which violent lunatics are confined.

The two concluding lectures will be given in following numbers of our Supplement.

THE NEW YORK BELTING AND PACKING COMPANY.

In this connection it will not be out of place if we give a few words descriptive of some of the processes and manufactures of the New York Belting and Packing Company,

whose rubber machinery is so well illustrated on our first page.

For belt making, the rubber coated and impregnated duck is taken to a large department where this branch of the business is carried on, and unrolled upon tables one hundred feet long, where the workmen cut it accurately to the required width. One strip is cut so that, folded, it will make the width of belt, and another so that the wide strip will just fold over its edges and meet in the middle, which makes a three-ply belt. In this way the strips are passed between a series of powerful rollers, the temperature of which is evenly regulated, as in all the other operations; the folding over at the sides makes an even and perfectly regular edge, and at the middle, where the edges of the outside strip come together, a narrow ribbon of rubber is fed to cover exactly the line of meeting. In this way the entire outside of the belt is pressed by the heated rollers into an even, regular surface.

The thicknesses of the regular sizes of rubber belts for most machine work are three-ply and four-ply, although two-ply belts are also made. The three-ply is generally compared with the heaviest single leather belts, and the four-ply with double leather belts. In making four-ply rubber belts, or in heavier ones when ordered, the width of the outside strip is calculated according to the two or more thicknesses over which it must be folded, and the operation then proceeds as in making the three-ply.

As the rubber surfaces, before being vulcanized, would stick together, they are rolled up with a thickness of duck between, and the rolling machine has an attachment which rolls up this fabric as the machine is fed.

Our engraving gives but an incomplete idea of the room which these operations take up, for the long lengths of belting which have to be prepared previous to going into the machine have then to be carried forward into the vulcanizing heater, and this operation must be continuous from the commencement until the vulcanizing process is complete. The company is now making an elevator belt thirty-six inches wide and half a mile long, which will weigh over eighteen thousand pounds. All of the great grain elevator belts in the country are of rubber, and the company have some of their big belts in Chicago elevators which have been running perfectly for twelve years. The metallic compound with which the rubber for belts is prepared gives its surface a high degree of firmness, while there is yet sufficient elasticity to allow of its hugging the pulley closely, which all machinists understand is necessary to enable a belt to work well; in the compound, also, as well as in the vulcanizing, attention is directed to making a belt which will resist a high degree of heat, so that the surface may not be injured by friction. All mechanics will understand that in putting on belts they should be stretched as tightly as possible, and in large belts, where joints are strengthened by overlapping a thin piece of rubber or leather, the seam side should always be outside; the closer the contact of the belt with the pulley, and the more perfect the exclusion of air from between belt and pulley, the better the service.

HOSE PIPE MAKING.

For the hose-making department, the general features of which are represented in one of our views, the rubber has its different and particular compounds in the mixing machine, and in the calendering is united with the fabrics suited to the different kinds of goods made here. The lengths and widths required are cut much the same way as in the preparation of belting, and then fitted over cylinders of twenty-five and fifty feet in length, which are rolled against other cylinders to press together and make solid the laps and joints under a powerful pressure and the requisite degree of heat These forming cylinders remain in the lengths of hose until the vulcanizing is completed. A great many kinds of hose are made, two-ply being the thinnest, and the sizes from half inch to ten inches internal diameter; hydrant hose is three-ply, and ordinary engine hose, to stand a pressure of one hundred to one hundred and fifty pounds to a square inch, is four-ply. Their "test" hose, made on carbolized duck for fire engine service, will stand a pressure of four hundred pounds per square inch. The advantage of rubber hose over that made of leather, aside from its much higher tensile strength, lies in the fact that it requires no care, only to be hung up to dry after use, while leather hose must frequently be "stuffed" with oil and tallow, etc., after the manner a currier finishes leather, only the stuffing must be forced inside the hose, making the operation more difficult. For these reasons the use of leather hose is steadily being relegated to the small country towns where only hand engines are used and where the volunteer firemen having ample time to devote to leather dressing.

In addition to the above the New York Belting and Packing Company manufacture suction hose, and steamer and brewers' hose, on spiral wire, one variety of which has the wire entirely embedded in the rubber, so that the interior is perfectly smooth.

The illustration showing where the square packing is made ready for vulcanizing gives only one of many different operations connected with this branch, The rubber is furnished in sheets and plates of different sizes and shapes for regular articles, either pure or with cloth insertion, but where irregular shapes and forms are wanted, which cannot be cut out of the standard products, they must be made in moulds, not cast, as many suppose, and the rubber, after having been prepared by mixing and otherwise, as in the other operations, must be pressed into the moulds. In this way the corrugated matting, stair pads, car springs, etc., are made. The demand for this packing in steam work, to pack around piston rods, and wherever there is a joint where the metal is subjected to different degrees of temperature, in valves, etc., is enormous, and only an engineer who has had experience with the materials formerly used for this purpose can fully realize its value for such use.

The making of gas tubes, shown in one of the views, presents no substantial difference in principle from hose making. This tubing is made either pure or with cloth insertion

EXPORTATION OF VULCANITE EMERY WHEELS.

The New York Belting and Packing Company have been receiving for some years large orders for their vulcanite emery wheels from England, where they are used in the Government arms manufacturing works at Enfield, near London. They have also, for a considerable time back, been supplying these wheels for the use of both English and Continental manufacturers of fine cutlery, machine tools, and implements of precision, their superiority over English emery wheels for nearly every kind of grinding, cutting, and finishing being thus practically recognized. The success of the company in this field, almost within the bailiwick, as it were, of a business in which England claims especial pre-eminence, is particularly creditable to its managers and to their goods, and cannot fail to be gratifying to American mechanics generally.

The solid emery vulcanite wheel is an American invention, to attain complete success in the manufacture of which the company devoted years of laborious application, making thousands of costly experiments, and constructing therefor elaborate and expensive machinery. It was a branch of the business which, starting with the most ample facilities, and using only the best rubber, presented peculiar difficulties, for the problem was far more complicated than any which came up in other departments of the vulcanizing process. Aside from the nice distinctions always necessary in the mixing and vulcanizing processes of the rubber manufacture, they had still more difficult points to overcome in making wheels which would be sufficiently strong to run at a circumferential velocity of from 5,000 to 7,000 feet per minute, and which would have only just enough rubber in them to bind the emery closely, so that the wheels would wear perfectly even without glazing, would not soften by heat nor become brittle from cold, and would be throughout of such uniform texture and density that their work could always be depended upon. How well they have succeeded in overcoming these difficulties, and also in perfecting the mechanical details for mounting, truing, and turning off wheels, the greatly increased demand affords the best proof.

There have been but few improvements which have within the past twenty years worked such important changes in the way of economizing work in the machine shop and finishing room as has been effected by the emery wheel. The many different grades in which it is made, each differing from the preceding by the slightest variations, fit it alike for almost every kind of grinding and polishing. Its handiness and general adaptability have enabled it to drive out the use of the grindstone, to a great extent, in the saving files to the value of millions of dollars, and greatly reducing the amount of work for which lathe tools were formerly used, so that it is now generally employed by workers in wrought, cast, and chilled iron, hardened steel, slate, marble, glass, etc. In the marking of hardware, cutlery, and edge tools it has become indispensable, while it has also effected a great saving of labor in the manufacture of plows, safes, stoves, agricultural implements, and small machinery of almost every description. It is, therefore, a matter of considerable credit to American inventive genius and mechanical skill that the rest of the world should be indebted to us for the introduction and continued manufacture of the best articles in so important a specialty.

THE GREAT STEAM PRESS.

In this connection considerable interest attaches to an immense steam press, the largest of its kind in the world, which the company have recently completed, and which is shown to the right at the bottom of the page. This press will take a belt six feet wide, and fifteen feet of its length, at once; it weighs 85,000 pounds; the steam is let into the bed and platen so that the temperature can be readily regulated; the platen is stationary, and the bed is lifted by hydraulic pressure. The most novel feature of this great press, however, is that it is arranged with appliances at each end for stretching the belts, so that, while the belt is under the full tension of the heaviest strain it may be desired to put upon it, it may at the same time be compressed between the hot plates, and thus set its fibers as firmly as a bar of steel. It does not seem very likely that an engineer would ever be troubled with having to "take up" a belt whose "stretch" had been taken out in this way.

The N. Y. B. & P. Company own the patent for this stretcher in combination with the press, as they do many other patents of great importance in the business. The principal Goodyear patent on vulcanizing expired in 1865, but this company had then been many years manufacturing, and had obtained subsequent patents for improvements, some of which are of great value in their present manufactory.

The offices, salesroom, and warehouse of the company are at 37 and 38 Park Row, New York. John H. Cheever is the treasurer of the company and general manager of the business.

THE CANADIAN PACIFIC RAILWAY.

WHEN British Columbia was admitted into the Dominion of Canada, nine years ago, the leading condition upon which the union was based was an agreement, on the part of the Dominion Government, to construct a railway connecting the Pacific coast with the eastern provinces. Since that time disputes between the Provincial Government and that of the Dominion, relative to its immediate construction and to the choice of routes, have been the cause of much local irritation and have greatly delayed the progress of the undertaking. Four years since, the Earl of Dufferin, as Governor-General of the Dominion, made a tour through British Columbia, and by his wise mediation succeeded in harmonizing conflicting interests and in bringing about a much better state of feeling; but it was reserved for the Dominion Premier, Sir John MacDonald, and the present government commissioners to put an end to sectional prejudices and to render inestimable service to their countrymen by insuring the immediate construction of the railway, and thus making the great question of the future of Canada no longer a debatable one.

The preliminary surveys have long been made and the route decided upon is familiar to most railroad men. Starting from Thunder Bay on the northwestern shore of Lake Superior, the first objective point is Rat Portage, or Keewatin, at the crossing of the Lake of the Woods; thence the line runs to Selkirk, on the Red River, twenty-three miles north of Winnipeg, the capital of Manitoba. It then spans Lake Manitoba and extends across the vast prairies of the northwest territory in a northwesterly direction to Northcote, at the northern end of the Duck Mountains; thence it takes a westward course through Brattleford and Edmonton, scales the Rocky Mountains at Yellow Head pass, follows the Thompson River and terminates at Burrard Inlet, which is situated just north of the mouth of the Fraser River and possesses three fine harbors in English Bay, Coal Harbor, and Port Moody, the latter being first reached from the interior. Near Port Moody is New Westminster, one of the most important towns of British Columbia.

The distances from the Pacific to the Atlantic by the new route are as follows: By the Union Pacific road from San Francisco to New York via the Michigan Central, Great Western and New York Central, the distance is 3,363 miles; from New Westminster to Montreal by the Canadian Pacific and the line to Montreal by way of Ottawa, it is 2,730 miles —a difference in favor of the Canadian route of 633 miles. From New Westminster to New York by the Canadian Pacific, Michigan Central, and Grand Trunk, it is 3,251 miles, showing a difference in favor of the Canadian Pacific of 521 miles. From San Francisco to Boston by the most available route it is now 3,422 miles, but from New Westminster to Boston the distance will be reduced to 3,087 miles, a saving in distance of 335 miles, and, comparing distances between Portland and the Pacific coast by different roads, we find that the difference in favor of the Canadian route is 521 miles.

A great deal of work has already been expended upon the line from Thunder Bay to Selkirk—a distance of 228 miles —and two branch roads have been completed and in operation for some time. One of them extends from St. Vincent to Winnipeg and connects with the St. Paul, Minneapolis and Manitoba Railroad, which runs from St. Vincent to St. Paul, and is destined to become one of the important factors in the grain transportation of the great northwest.

The preliminary surveys have long been completed and the difficulties encountered and overcome in making them have been enormous. The engineers traversed a vast continent which had hitherto been unknown except by fur traders, roving Indians, and a few devoted missionaries. They knew by report that this great expanse was a country intersected by numerous streams and dotted with many lakes; that it was a rocky territory densely wooded for the most part and without a single white inhabitant. Beyond the scanty information obtained from the early missionaries, who had visited it intent upon benevolent enterprises, the engineers have given us the only accurate information of the country west of the Red River that we possess.

The exploration of a portion of the country was a matter of comparative ease, but when the Rocky Mountains were reached, various obstacles presented themselves One large party of engineers spent nearly two years in trying to find a suitable pass through these formidable barriers and through the hills that lie within the bend of the Columbia River. An immense amount of extra labor was imposed upon the surveying parties on account of differences of opinion between government officials as to available routes.

Forty-seven thousand miles were actually passed over under circumstances of the greatest difficulty and danger. Some of the engineers were surrounded by forest fires and burned to death; others lost their lives in trying to cross dangerous rivers, and others died from the effects of exposure sustained in spending winters in the bleak mountains in the midst of deep snow, with only the shelter of canvas tents. In all, forty lives were lost, and in addition to the actual traveling of forty-seven thousand miles of distinct routes in search of the best way, there are actual instrumental surveys, laboriously measured yard by yard, of more than twelve thousand miles; nearly five times the length of the road when completed to the Pacific coast. These preliminary surveys cost about four millions of dollars, and when we consider that they were practically completed in the space of six years we cannot overestimate the zeal, the ability, and the heroic fidelity of the persons who accomplished such results.

With regard to the future of the railway, we are told that the contract for the construction of the line is taken by a syndicate said to be the most powerful in respect to money and influence that has ever taken hold of any American enterprise. Three sets of capitalists seem to have been working for this contract, which bartered for work to be done a vast empire of undeveloped land in the northwest territory. One was led by Lord Dunmore and Brown & Puleston, bankers; another by George Stephen, president of the Bank of Montreal, R. B. Angus, Hon. Donald Smith, Winnipeg, and American capitalists; and the third by Lord Dunraven, Hon. Thomas Brassey, M.P., and others. The information received states that Sir John MacDonald has united the competing interests by adding a cash bonus to the land grant, although he has retained control over the greater portion of the land so as to prevent it being held other than by *bona fide* settlers.

The contracting parties will receive from the Canadian Government a certain number of millions sterling in cash or its equivalent, to be provided for by an issue of Canadian Government bonds and a certain number of millions of acres of land. In consideration of these grants, they undertake to form a company, to be called the Canadian Pacific Railway Company, which shall construct and work the line in perpetuity. The government furthermore gives to the contracting parties in addition to the surveys already made the whole of the line already built. Of the immense advantage of the railway, when constructed, to the Dominion of Canada there can be no doubt. Although, on account of sectional jealousy and perplexity in deciding upon routes, progress has been long delayed, the preliminary matters of the railway have been planned and executed with consummate skill and ability.

The line throughout its whole extent will compare favorably in all important particulars with our own trans-continental lines. It will run through the mountain passes by low lying passages which do not exist in more southern routes. The engineer-in-chief, lately in charge, has reported a location on which, for fully a thousand miles west of Lake Superior, the easterly ascending gradients can be kept down to half the maximum gradients on the Grand Trunk and other roads in operation in the older provinces, thus insuring to a certain extent cheap transportation. The habitable land of the great undeveloped interior is not confined to a narrow belt along the valley of the Saskatchewan, but recent explorations have shown it to be immense in area and abounding in resources which will now be disclosed and turned to account. The vicinity of the great coal fields of Pennsylvania and Michigan to Lake Erie and Lake Huron, will enable Canada to develop her mineral deposits and make them available, and she will now be able to carry her grain and lumber to market. England will send over farmers and artisans, and will confidently expect that what has remained until recently almost a desert, traversed annually by migratory herds of antelope and buffalo, and only available for wild Indians and hardy trappers, will become ere long the seat of populous provinces, and will constitute, if not the most valuable of her colonies, at least one of the great granaries of the world.

MEASURING THE WEAR OF RAILS.

THE engraving on next page represents a handy little apparatus for measuring the wear and tear of rails, which is the invention of M. Wm. Kraft, of Vienna. This apparatus has been chosen by the Technical Commission of the Society of German Railway Directions as the best out of a number sent in for approval. It consists of two main parts, one of which is the footplate, which is wedge-shaped, with two grips ten centimeters long on the broad end. In the narrow end is a slot, into which a clamp, *g*, is slipped when the plate is under the rail. The screws, *b*, *c*, and *e*, complete the attach-

Fig. 5.

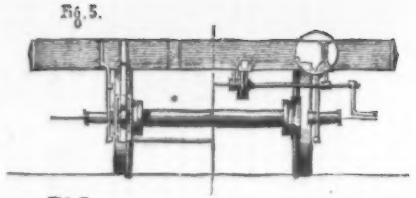


Fig. 1.

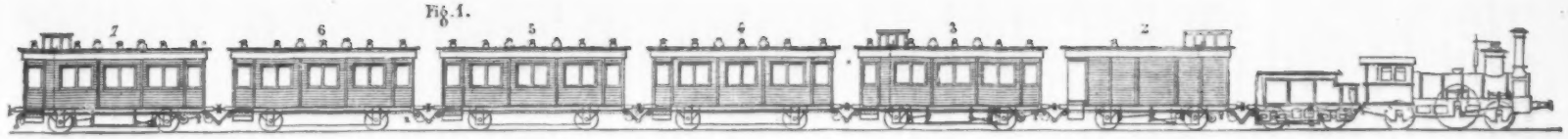


Fig. 6.

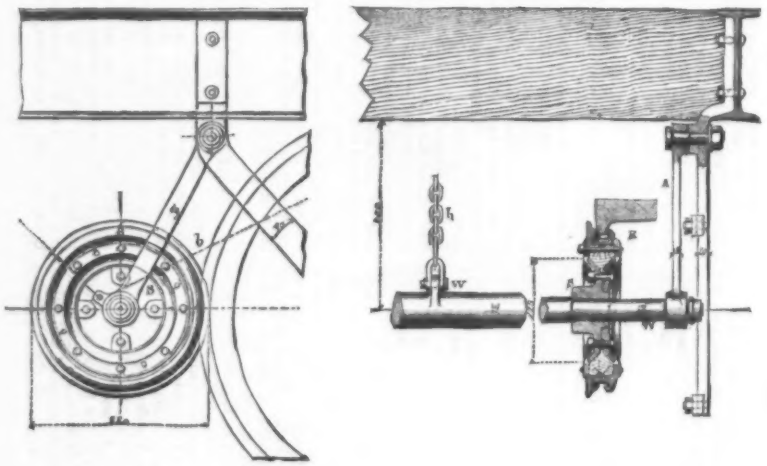


Fig. 2.

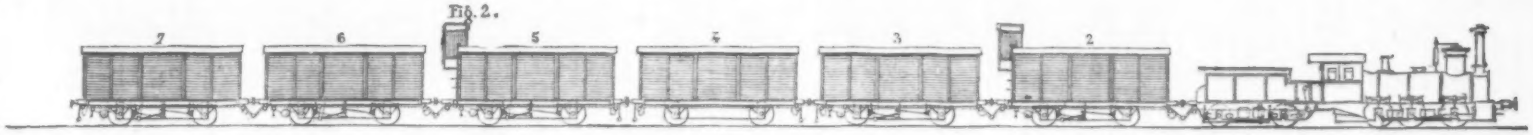


Fig. 12.

Fig. 4.

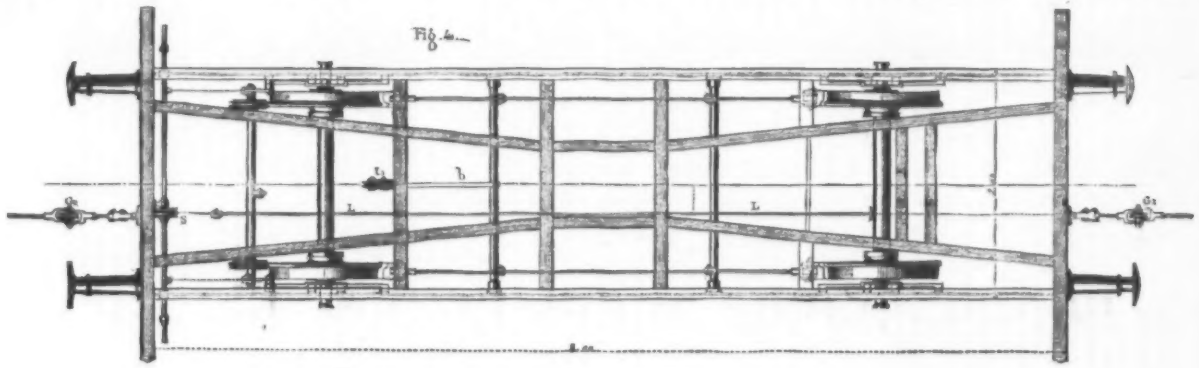


Fig. 10.

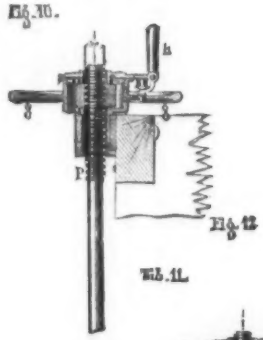


Fig. 12

Fig. 11.

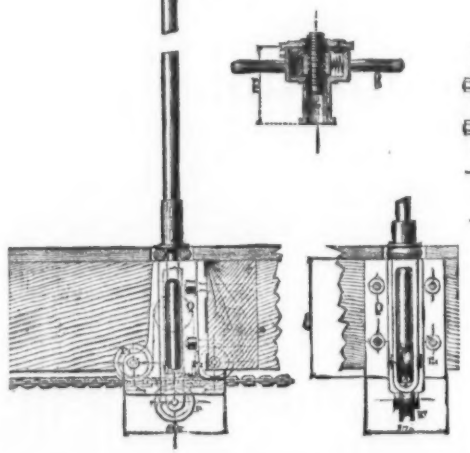


Fig. 3.

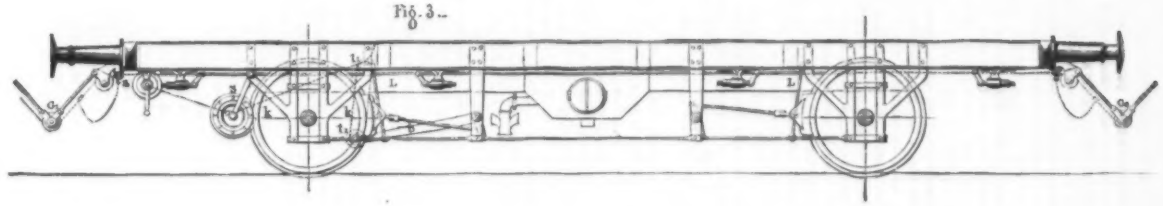


Fig. 7

Fig. 8.

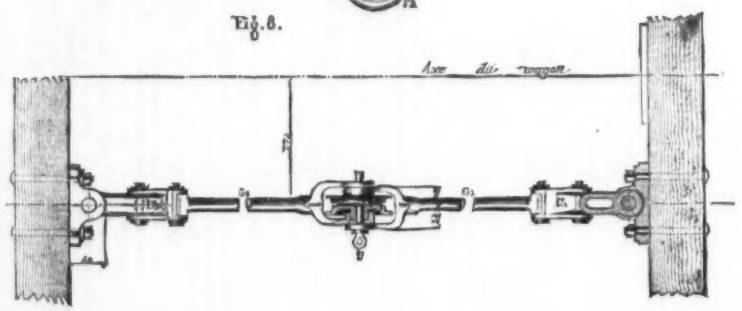
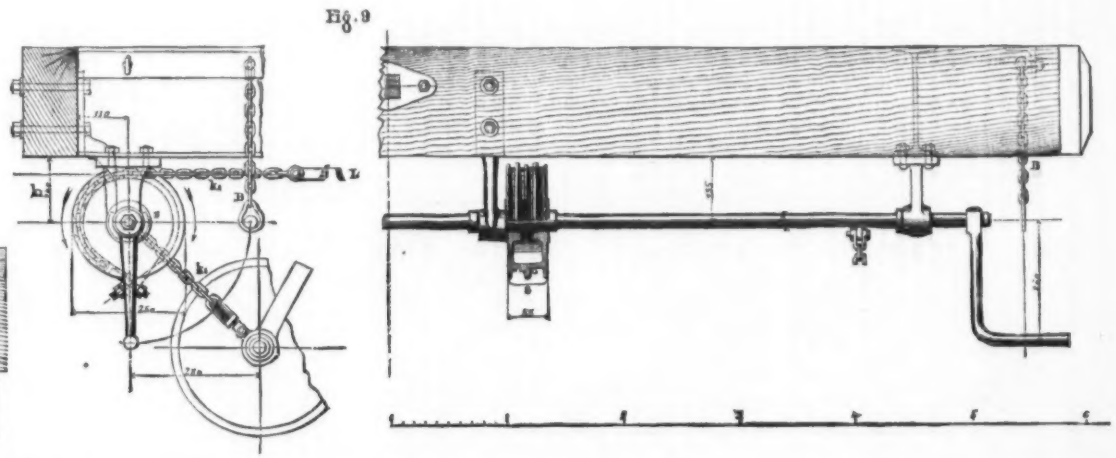


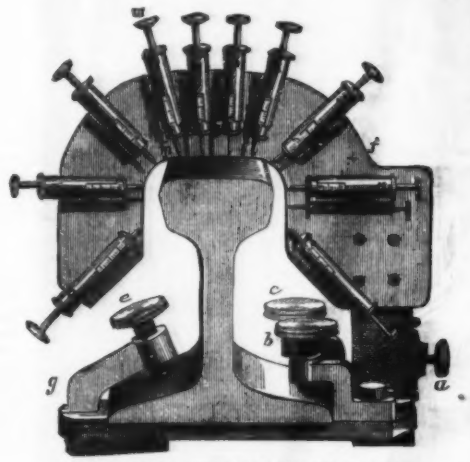
Fig. 9



AUTOMATIC FRICTION BRAKES.—NORTHERN RAILWAY OF AUSTRIA.

Fig. 1.—Application of the Continuous Brake to a Passenger Train. Fig. 2.—Application of the Brake to Cars in Groups. Figs. 3, 4, 5.—Method of Fitting the Brake to the Frame of a Car. Elevation, Plan, and Transverse Section. Fig. 6.—Apparatus for Tautening the Chains. Figs. 7 and 8.—Jointed Connecting Rods. Elevation and Plan. Fig. 9.—Starting Apparatus. Fig. 10.—Brake Controller. Vertical Section. Figs. 11 and 12.—Hand Wheel. Vertical Section and Plan.

ment. A rectangular pedestal, *d*, is fixed to the footplate with a set screw, *a*, for receiving and fastening the shank attached to one side of the plate, *f*. The measuring apparatus consists of a metal plate, *f*, to which the outside socket-tubes, *l*, of the ten measuring pins, are fastened according to the normal section of the rail. The pins are always kept pressed outward by spiral springs in the sockets, *l*, and as the points cannot project beyond the inner edge of the plate, *f*, they are protected from injury. In measuring the altered profile of a rail the apparatus is applied as shown in the engraving, the inner socket, *w*, being pressed home to the



MEASURING THE WEAR OF RAILS.

zero of the vernier on the outer tube, *l*. The pins, *m*, are then pressed downward until they touch the surface of the rail. In descending, they carry the inner socket tube, *w*, with them. On removing the pressure the pins fly back, but the inner socket tubes remain in their altered position, and the wear and tear of the rail can be measured by the vernier and scale on the inner tube to one-tenth of a millimeter. As soon as all the points have been pressed down, the plate, *f*, can be removed, and the altered form of the rail read off in any convenient position.—*Iron.*

BECKER'S AUTOMATIC FRICTON BRAKE.

THIS brake, the invention of Inspector L. Becker, of the Northern Railway of Austria, consists, as will be seen from the opposite engravings, of: (1) an apparatus for tautening the chains; (2) a starting apparatus; (3) jointed connecting rods; and (4) a brake controller.

(1.) *The Apparatus for Tautening the Chains.*—This apparatus (Fig. 6) is composed of a spindle, W, suspended from side-rods, A, which are connected by a joint with the guard-plates of the car. On this spindle are keyed two cast iron pieces, S, bolted together, and each provided with a loose ring, R. The latter is lined internally with a small rim of hard wood. When this ring comes in contact with the flange of the wheel of a car under way, a rotary motion is imparted to it, as well as to the spindle, W. The latter then winds around it the chain, *b*, thus operating on the brake-blocks, through the intermedium of the levers, and causing them to press against the tread of the wheels. Although the ring, R, is loose, it revolves about S with strong friction in such a way as to carry it along until the brake-blocks are drawn up firmly against the wheel; thereafter it revolves alone with the flange, so as not to break the chains.

(2.) *The Starting Apparatus.*—The object of this is to either remove the pressure of the tension apparatus from the wheels, or the contrary. Around a two-channel pulley are wound in opposite directions two chains, k_2 and k_3, the ends of which are fastened to the rundle. One of the chains, k_3, is fastened to a drag-bar, L (Figs. 3, 4, and 9), sliding in guides placed under the platform of the car, while the other, k_2, is hooked to the drag-bar of the neighboring car. The pulley, *s*, and the tension apparatus are connected by the chain, k_1. When a strain or a thrust comes on the drag-bar, L, the chain, k_1, unwinds or winds up, through the effect of the rotary motion communicated to the rundle, *s*, and removes the friction roller, S, from the tread of the wheel, or draws it up against it. The axle that carries the two-channeled pulley is provided with two winches by means of which the brakes may be operated by men on the track when the cars are being moved about at stations.

(3.) *The Jointed Connecting Rods.*—It is very essential that the braking apparatus shall not be subject to the relative motions of the cars, and which, so to speak, are continuous in a train under way, on account of the elasticity of the buffer-springs and draw-springs. And it is also essential that the chains shall not undergo any strain when the cars tend to separate a little from each other, while it is at the same time necessary that they should remain taut when the cars approach each other. For this reason M. Becker connects the cars by the apparatus shown in Figs. 7 and 8. Each of these consists of two rods, G_1 and G_2, connected by joints at their upper extremity to the supports U_1 U_2, and moving freely on the vertical axis, M. Two pulleys, P P_1, are mounted on U_1 U_2. The third pulley, P_2 is in two parts, but forms after coupling a single pulley. The axle-pin, *b*, serves to join the two rods, G_1 and G_2. One of these rods is provided with an extra axle-pin, b_2, so that the first can at once be replaced in case of loss or breakage. In order to repair a breakage of the chains without delay, the support, U_2, is furnished with a piece of chain twenty-eight inches long, with hooks. The coupling of these chains between the cars is effected with rings and hooks.

(4.) *The Brake Controller.*—The brake is managed either on a tender or in a brake-van. The brake-chain which is connected with the drag-bar, L, (Figs. 10, 11, and 12), passes between three pulleys, *r*, r_1, and r_2. The two last are fastened on the cast-iron support, Q, while the pulley, *r*, is fixed solidly to the spindle, *p*, and takes the rectilinear motion which is given the latter when the hand-wheel, *g*, is turned. According as the spindle, *p*, is raised or lowered the drag-chain tightens up or slackens, and consequently closes or opens the brake. The nut in the center of the hand-wheel is made in two pieces, so that if an accident should happen, it would be only necessary while holding the wheel with the left hand to unfasten the winch with the other and shove it toward the right, when the nut would separate, the spindle, *p*, would fall by its own weight, and the friction ring, S, would immediately abut against the flanges of the car wheel and thus lock the brakes.

Becker's system may be used (1) as a continuous brake; (2) as a brake for cars in groups; and (3) as a brake for a single car. As a continuous brake, all the brakes of the trains are operated by one person—either the engineman or the conductor. It is managed like an ordinary brake, that is, by unfastening the hand-wheel when it is desired to lessen the speed of a train or to bring it slowly to a stand still. It is only in cases of great danger that the nut is to be loosened so as to cause an immediate and sudden stoppage. Although the engineman can operate all the brakes of the train, the apparatus is so arranged that he can apply a brake to the tender alone. Freight trains being usually of considerable length, the brakes may be arranged on cars in groups so that a single person may brake each group (Fig. 2). A single car is managed the same as a train, when it is provided with all the essential parts of the apparatus.

This system evidently cannot compete as to efficacy, and as to rapid and energetic action, with vacuum and compressed air brakes; and moreover it has the disadvantage inherent to all systems of chains and levers of rattling during the journey. But as an offset to these faults it presents some advantages worthy of consideration: (1) It is simple in construction and does not easily get out of order; (2) broken parts can be replaced at once and without difficulty; (3) the brake may be used on single cars at stations, this being an advantage not possessed by air and electric brakes; (4) it requires less material, and consequently costs much less than other systems. For a train composed of a locomotive and tender, three experimental vans, and six passenger coaches, the different systems will cost as follows: Steel, $1,680; Westinghouse, $1,144; Smith, $1,080; Heberlein, $734; Becker, $460.

CARE OF HEATING APPARATUS.

THE Secretary of the Treasury has issued the following instructions for the guidance of engineers and firemen in charge of the heating apparatus in public buildings.

HOT-WATER HEATING APPARATUS.

The entire apparatus must be kept filled with water during the entire year. The engineer must ascertain this fact by examining the open reservoir at least once every day.

The apparatus must not be left without heat when the temperature is sufficiently low to freeze the water in the pipes, and no portion of the apparatus must be closed off for repairs during freezing weather unless the water in that portion shall be immediately drawn off.

Cold-air dampers both to direct and indirect radiators should be closed at night in those portions of the building that are not occupied.

Air valves on top of radiators should be opened at least twice every day, to prevent the accumulation of air which interrupts the circulation.

Fire should never be made in apparatus until it is entirely filled with water.

Valves must never be placed on main flow and return pipes from boilers for the purpose of isolating the boiler from the apparatus.

Alkaline waters should never be used in apparatus, and muddy waters avoided. In situations where that character of water is used, at the end of each season a portion of the water should be blown out of the draw-off valve, in the return pipe in boiler, in order to clean out any sediment which might collect there. The weight of the head of water will be sufficient to move any ordinary deposit of this character.

At the end of each heating season the apparatus should have a thorough cleaning; the radiators, both direct and indirect, should have the dust removed which may have accumulated on their surfaces as far as possible. Ashes and soot should be cleaned from flue under and in rear of boiler, and the deposit taken out of smoke flues. The flues of the boiler should be thoroughly cleaned.

Where boilers are exposed to dampness, the flue doors of boiler front and the manhole doors in rear of boiler in brick should be left open to allow the circulation of air through the tubes, to keep them as dry as possible.

LOW-PRESSURE STEAM-HEATING APPARATUS.

Fire should never be made under the boiler until it is ascertained that the boiler has three gauges of water above the flues, and this amount of water should be kept in the boiler at all times when the apparatus is in operation.

All the safety appliances attached to the apparatus must be tested by the engineer at least once every day when the apparatus is in operation; the lever of safety valve must be lifted to see that it is in working order. The drip from water gauge must be blown out to see that no sediment has collected in connection pipe. All the levers and attachments to the automatic-damper regulators must be kept well oiled and in perfect working order. In addition to these precautions, the gauge cocks must be opened at regular intervals.

The apparatus must not be left without heat when the temperature is sufficiently low to freeze the water in the boiler. When it is desirable for purpose of repairs, or the apparatus is not required in such weather, water must be entirely drawn from every portion of it. In drawing the water from the apparatus at such times, care must be taken to open all of the drips to radiators, risers, and main pipes, while they are sufficiently heated, to allow all of the condensed steam to escape.

Cold-air dampers to direct and indirect radiators should be closed at night in those portions of the building that are not occupied, and, when in use, regulated to suit the temperature and velocity of the wind.

Air valves, if not automatic, must be opened whenever the heat is first turned on to the apparatus, in order to empty the radiators of air.

Alkaline water should never be used in the apparatus, and muddy water avoided. In situations where that character of water is used, the boilers should be blown off at least once every day when the steam is at its maximum pressure, for a period of a minute or less, as may be required, in order to prevent accumulations in the bottom of boiler and in return pipes.

Anthracite coal should be used in all situations where the same can be obtained, and where bituminous coal is used the flues must be cleaned proportionately oftener, to prevent the rapid accumulation of soot.

At the end of each heating season, the apparatus should have the dust removed which may have accumulated on their surfaces during the season. The ashes and soot should be cleaned from the flues under and in rear of boilers, and the deposit out of the smokestack; but where boilers are exposed to dampness the flue doors in the boiler front, and the manhole door situated in brickwork, in rear of boiler, should be left open to allow circulation of air through the tubes in order to keep them as dry as possible.

Five lb. pressure is the maximum to be carried on low-pressure heating apparatus.

A SHIP CANAL ACROSS CAPE COD.

A JOINT committee of the Massachusetts Legislature was appointed early in the spring of 1860 to consider the project of cutting through the Isthmus of Cape Cod, and for the purpose of navigation connecting Buzzard's Bay with Barnstable Bay by a ship canal. The committee found that the subject which it was ordered to investigate had for a long time agitated the public mind, and that during the last one hundred and fifty years it had been repeatedly presented to the Legislature as an improvement demanded in the interest of general economy. The committee reported that the construction of a ship canal, with the requisite harbor improvements, of ample capacity for the entire coasting trade of the United States, was a practicable enterprise, and that when constructed it would become the thoroughfare of the coasting trade, shorten distance, save life and property, and materially reduce the cost of transportation, and that the cost of construction would not be excessive, but would fall far below its value to navigation when completed.

Despite this report, however, and the interest taken in the matter by many prominent New York and Boston capitalists, nothing was done in the matter until within the last few months, when A. G. Fisher, a commission merchant and ship broker of this city, became interested in the scheme and found little difficulty in enlisting New York capital. A company was formed, and $8,000,000 of capital subscribed, of which sum $1,500,000 has already been paid in. The contract for building the canal has been given to Adam Driesbach and John Cameron, of New Jersey, and these men, accompanied by Geo. H. Titcomb, started Wednesday morning for the scene of operations.

The proposed route of the canal has already been surveyed by the engineer-in-chief, Geo. H. Titcomb, and under a contract granted by the Legislature, which has not yet expired, the new company has secured a strip of land one thousand feet in width along the whole distance through which the canal is to run. The starting point of the canal will be near the little village of Sandwich, and in the coming week five hundred men will be forwarded to that point, and the work of excavating will be begun. Before the end of the month it is expected that two thousand men in addition will be put to work. The canal will be seven and three-quarter miles long. The general direction of its course is from northeast to southwest. It is bounded by two ranges of wooded hills, varying from sixty to one hundred and eighty feet in height; at its narrowest point, four miles below Black River Harbor, it will be over two hundred yards wide, and it gradually expands from this point in both directions.

The bottom of the valley rises with regularity to a height of twenty-five feet, and the greatest elevation is at a point five miles from Buzzard's Bay. From this point it descends to Cape Cod Bay, there being a difference of about two feet in height between the two extremities. The soil of the valley consists mostly of gravel, and is therefore easy of excavation. The average value of the land is at present about $7 an acre. At the southwest end of the valley stands the village of Monumet; near the middle of the valley is North Sandwich, and at the northeast end is Scusset. Almost the entire length of the valley is watered by the Monumet and Scusset Rivers.

Great advantages, it is claimed, will be derived from the building of the canal. There will be a saving of ninety miles in the distance, and eight hours in time between this port and Boston, and the great dangers of navigation in crossing Cape Cod will be averted. It is estimated that there is an average annual loss of six thousand tons of vessel property, and of from thirty to forty lives, caused by the shipwrecks occurring around Cape Cod. The canal will be one hundred and forty-one feet wide at the top and six feet wide at the bottom. It will have an average depth of thirty-five feet.—*N. Y. Tribune.*

THE CAPE COD CANAL.

THE Boston *Traveller*, September 4, publishes the following from a correspondent at Sandwich, Cape Cod:

The Cape Cod Canal, after two hundred and fifty years' talk, now shows the promise of becoming an accomplished fact. The company that was organized and incorporated about twenty years ago has preserved its vitality, though sometimes in a state of suspended animation. During the present season the surveys have been going on with renewed vigor, and the results have been worked up by competent engineers, until now the whole route is very nearly definitely located. The last question to be decided is as to the location of the harbor on the Massachusetts Bay side of the Cape. Near the town of Sandwich there are two small rivers which enter the bay; one is the Scusset and the other is the Shawm. They are only two or three miles in length, and though very tortuous in their course, they are very nearly parallel in their general direction. For the most part they run through the level salt marshes and are filled and emptied by the ebbing and flowing tide. They each offer a poor shelter at their mouths for small coasters. The Shawm is the Sandwich harbor, the Scusset is a harbor for a limited wood trade with Boston. The mouths of these two rivers or creeks are not more than a mile apart; but the rivers are separated through most of their course by a long ridge of land, which commences at the beach and runs in a westerly direction. The ridge is nearly a mile long and half a mile wide, and possibly seventy-five feet in height at its greatest elevation. It is called Town Neck, and has been owned in common from the time when the town of Sandwich was first settled, say for about two hundred and forty years. It has never been cultivated, and has been used for a cow pasture, and is still devoted to that purpose, supplying feed for seventy head of cattle. The question now is whether the canal shall have its Massachusetts Bay opening at the north or Scusset side of this ridge, or on the south or Sandwich side. This question will be decided within a very few days, and probably in favor of the Sandwich side, since the facilities for the construction of a safe and commodious harbor favor this location. There must of necessity be a breakwater or jetty, and as the sweep of the tide is southward and eastward from Plymouth, past Sandwich, onward to Barnstable Bay, and since from the point where the Town Neck touches the beach there is a natural deposit of bowlders, which runs from the shore northeasterly, and terminates in a ledge about half a mile from the shore, it is thought at a comparatively small expense the necessary

SWANSEA AND PLACES IN THE NEIGHBORHOOD, VISITED BY THE BRITISH ASSOCIATION.

breakwater may be built out from Town Neck to the ledge, at which point the water reaches an average depth of about fifty feet. Most likely, in view of the set of the tide and the general configuration of the shore, only one breakwater will be needed to supply all the coaditions of a perfectly secure harbor.

It is a fact worthy of notice that the tide in Massachusetts Bay at high water is eight feet higher than the tide at high water in Buzzard's Bay. The canal will be not far from nine miles long, and as there are to be no locks at all, there will be a constant current of about two and one-half miles per hour setting from Massachusetts Bay into Buzzard's Bay. The good people of Boston need not fear that this continual drainage will leave Boston high and dry, as the Atlantic Ocean will supply whatever loss may occur. With this straight, unobstructed passage through the canal, steamers for freight and passengers will be able to leave Boston at five or six P.M. and reach New York at seven A.M. the next day, making the route to New York one of the most beautiful excursions by water possible, and ocean steamers from and to New York and the various European ports will be able to make the passage and save from eight to ten hours each way.

SWANSEA AND ITS NEIGHBORHOOD.

THE Congress of the British Association for the Advancement of Science was held, August, 1880, at Swansea, and the members and visitors enjoyed the customary excursions in that neighborhood, visiting the places of which we present some illustrations opposite.

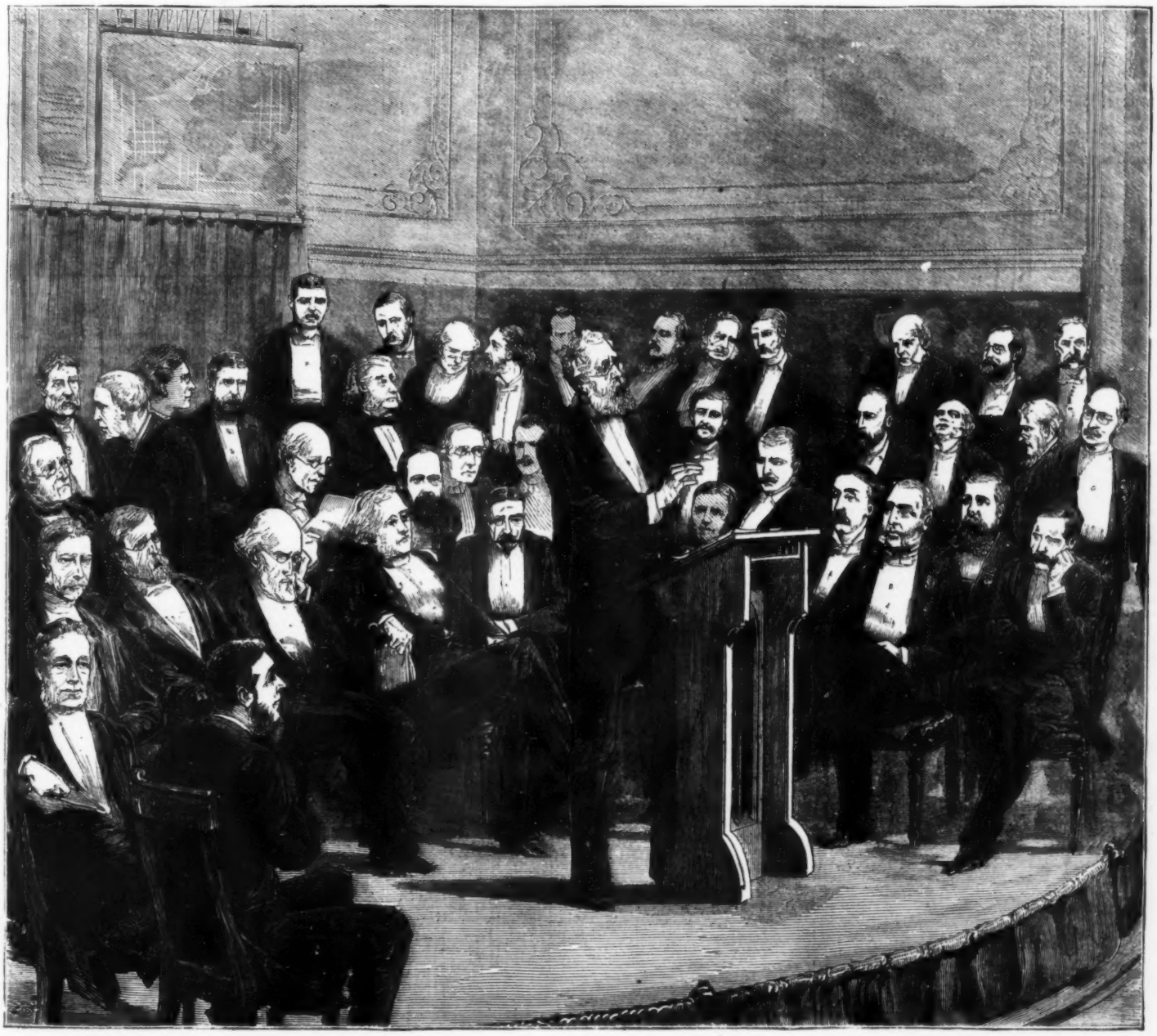
Swansea Bay, which is by nature very beautiful, with fine wooded hills rising behind it north and west, receives the small river Tawe, upon which the town is built. A few miles east of this, at Briton Ferry, is the outlet of the Neath, the valley of which, by its coal and iron mines, supports a large industrial population. Swansea has, within the last forty years, grown up to be one of the greatest metal-producing and metal-working towns. Its copper-smelting, iron and steel works, zinc and spelter, and manufacture of tin plate, at the Swansea Vale, Landore, and Morriston establishments, draw supplies of ore from all countries, and send their products all over the world. The population of the town, which was under 20,000 less than forty years since, has increased to 80,000. There is a considerable export of coal, and the trade of this port bids fair to rival that of Cardiff; an artificial harbor or tidal basin, with docks, affording good accommodation for shipping, has been constructed, and other such works are in progress.

The town, apart from these commercial and industrial sources of wealth, is pleasant enough in its western part. On the hill slope that rises from the right bank of the Tawe, there is the remnant of an old castle, which has seen a good deal of fighting in former ages, both when the Norman barons and knights held South Wales against the native princes, or in the Owen Glendower rebellion, and in the wars of Cromwell and the Royalists in the seventeenth century. Parts of the castle have been used at various times for a bishop's palace, a market-place, a townhall, a chapel, a store-house, and a post-office. The keep, with its ornate parapet, added in the fourteenth century by Bishop Gower, of St. David's, is still in good preservation. Swansea has several local institutions of merit; the Royal Institution of South Wales, with its museum and library, and an excellent grammar school, are perhaps the most important. There is railway communication with England by the Great Western, the London and North-Western, and the Midland Railway systems.

Excursionists from Swansea, either by traveling westward through the pretty village of Sketty and over the hills, or by crossing the bay to Oystermouth, get into a very attractive and interesting region. Oxwich Bay, on the southern shore of Gower, twelve miles distant from the town, offers plenty of things worth seeing. To the scientific people of the British Association, it is presumed, there will be an especial subject of study in the Bone Caves. These resemble the bone caves of the South Devon coast, with their deposits of remains of extinct animals, supposed to have been carried there by the carnivorous beasts of a remote paleontological era. Oxwich Castle, built probably in the reign of Henry I. by Henry Beaumont, Earl of Warwick, called Henry de Newburgh, and Penrice Castle, which passed from the Pen Rhys family in 1400, by marriage, to that of the Mansels, are not the only ruins of feudal strongholds in this district.

The one shown among our illustrations is Oystermouth Castle, opposite the Mumbles; it has a noble situation upon an eminence overlooking the bay, and sheltered by the rugged limestone cliff. It belongs to the Duke of Beaufort, who has taken good care of this relic of the Middle Ages. The general plan of the fortress is quite distinguishable; it was of polygonal form, but something triangular in ground plan, with lofty ramparts, but no bastions or flanking towers, except at the chief entrance, on the south-west side, which has a wide portcullis gate defended by advanced towers. The great hall and the chapel, with their Gothic windows of ornamental tracery, are in a tolerably perfect condition. It was probably more a feudal mansion, or military governor's residence, than a fort destined to experience the actual shock and brunt of warfare. The ancient Norman church at Oystermouth, or partly Norman, part Early English, is another token of the dignity of this village as the capital of the province of Gower, long before Swansea became an important town. The name of the place is a corruption of some words in the Celtic language, meaning the mustering-place of an army. The name "Gower" is said to mean "curved" or "crooked," referring to the shape of this singular peninsula of the Glamorganshire coast. It should be noticed, as an interesting historical fact, that the rustic and seaside population of this district are not Welsh people by race, but of Flemish origin, the descendants of a colony of Flemings, refugees to England under the early Plantagenet kings, transplanted hither by royal policy to hold this piece of country against the Welsh nation.

The Mumbles lighthouse, erected in 1794 as a beacon of safety for mariners in the Bristol Channel, is shown in one of our sketches engraved. The roadstead here has much commodiousness, with room and shelter for all the small coasting-vessels at once behind the promontory and the two little rocky islands, which are accessible by wading or



Professor Gunther, President of the Biological Section. Professor Ramsay, President. James Strick, Esq., Local Hon. Sec.
Professor A. Williamson, General Treasurer. Dr. Allman, Retiring President. J. E. H. Gordon, Assist. General Secretary.
Capt. Douglas Galton, Gen. Sec. J. P. Jenkins, Esq., Mayor of Swansea. Dr. P. L. Sclater, Gen. Sec. Hussey Vivian, Esq., M.P., Glamorgan.

PROFESSOR RAMSAY DELIVERING HIS PRESIDENTIAL ADDRESS IN THE MUSIC HALL.

THE BRITISH ASSOCIATION AT SWANSEA.

The district of Gower, to use the old historic Welsh name which is still popular with its inhabitants, is that peninsula of the coast of South Wales formed by Swansea Bay, to the east, and an inlet of Carmarthen Bay to the west, being part of the county of Glamorgan. It is about twenty-five miles long, and from five to eight miles wide. Its shores consist of rugged and rocky cliffs, chiefly of limestone, which assume picturesque and romantic shapes; and the small islets called the Mumbles, near Oystermouth, at the south west extremity of Swansea Bay, have long been noted as a striking feature of seacoast scenery. The Gower peninsula is exactly opposite to Ilfracombe and Lynton, on the North Devon coast, and is quite visible across the Bristol Channel at a distance of twenty-five miles.

walking from the mainland at low tide. Outside the headland, over a shoal, reef, or sand-bank, called the "Mixon," the sea at flood runs very high, and with great violence, in stormy weather, making it a dangerous place for ships.

Our principal view is that of Swansea, as beheld from the sea, with its harbor formed by two sea-walls, two hundred and fifteen feet apart, extending forward nine hundred feet from each bank of the mouth of the Tawe; its docks, the north and the south dock, the sea-float and half-tidal basin; its spacious quays and warehouses, its railways upon lengthy viaducts, its factories, foundries, and blast-furnaces, all presenting a business-like, nineteenth-century aspect. A range of the blast-furnaces is also shown in a separate illustration.—*Illustrated London News.*

ON GAS GENERATING FURNACES.*

By F. LURMANN, of Osnabrück.

IT is not my intention to enumerate to-day all the various gas generators in operation, but only to show the differences in their construction, and to draw your attention to Mr. Gröbe's recent improvements thereupon.

Heating arrangements, if blast furnaces are not taken into consideration, may be divided into two classes, viz.: those with grate firing, and, secondly, those with gas firing.

The difference between these two classes consists mainly in the admission of the atmospheric air (which in the case of grate firing takes place only at one point) through the grate, while in the case of gas firing it requires a second and separate point of admission. In a theoretical way, it might be argued that the combustion in an ordinary grate also constitutes a gas heating arrangement, as all solid parts of the fuel are first converted into gases, which are then burnt. Thus from coal about thirty per cent. of its entire weight is expelled on the grate in the form of hydrocarbon gas, and burnt as such, the remaining solid coal or coke also being converted into gas (carbonic oxide, and burnt to carbonic acid). Grate firing, considered in this way, however, also admits the atmospheric air only at one point, namely, through the grate.

If the layer of fuel on the grate is sufficient in thickness, so that the carbonic acid produced by the combustion of fuel in the lower part next to the grate can only pass through the redhot fuel above it, and again combine with carbon, thus

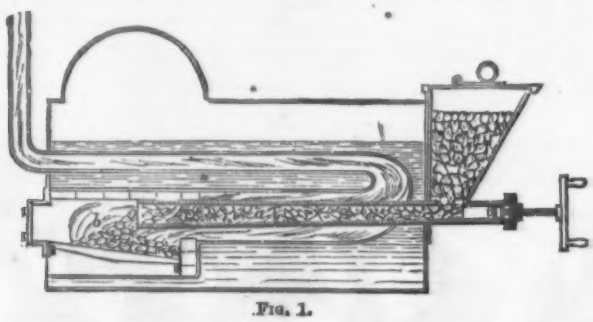


FIG. 1.

preventing the passage of unconsumed oxygen, we then have, speaking from a technical point of view, a gas generator, as the gases produced necessitate the admission and admixture of atmospheric air at another point besides through the grate.

Most of the generators now in use took their origin in this way. They consist of a single chamber, in which the two processes (1) of expelling the hydrocarbon gases (already formed in the fuel), and (2) of converting the remaining solid fuel, take place together, and these generators therefore have this drawback in common with ordinary grate firing.

So far back as forty years ago experiments were made to perform these two processes, requiring such opposite conditions, separately, and John Juckes was the first (see his patent, November 8, 1838, No. 7858, and annexed sketch, Fig. 1) to endeavor to improve the heating by preventing the disturbing influences which occur in ordinary grate firing by the charging of wet cold fuel on the hot fuel in process of conversion.

This arrangement constitutes only a grate and not a gas firing, because air is admitted only through the grate. As the horizontal chamber for expelling the gases is fixed in the converting chamber of the grate, the necessary heat for expelling the gases from the newly introduced fuel and for drying and warming the same is taken, as in all other grate firing and generators constructed hitherto, from the heat before it enters the combustion chamber. For the heating of steam boilers, which Juckes specially describes in his patent, this arrangement is quite suitable, as the expulsion must take place some time, and cannot be done otherwise than by the heat produced by the conversion the

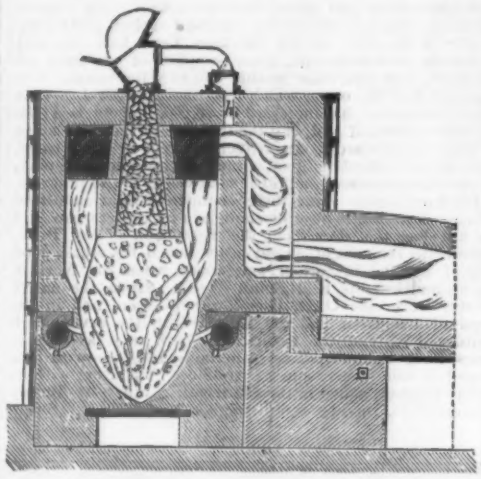


FIG. 2.

waste heat not having the required temperature left to perform the duty.

A very similar arrangement is that of John Price, of which a sketch is shown in Fig. 2, and for which he obtained a patent (No. 3462) on October 24, 1873. It also forms only a grate firing, air being admitted only through the grate at *b*; but it differs from Juckes' in not having a mechanical feeding arrangement, and the expulsion chamber being heated by waste heat. This arrangement, although still subject to some of the wants of all grate firing, has given very satisfactory results, as I have learned from the reports in the technical papers.

Another arrangement is that of M. E. Minary, of Besançon, particulars of which were published in the year 1868 in the *Publication Industrielle*, and a sketch of which is shown in Fig. 3. This is a real gas generating furnace, air being admitted at two places. The expulsion in *a* does not take place in a chamber separate from the conversion chamber, *b*, but in an elevation of the same, and the heat for expulsion is drawn from the heat produced by conversion. A large quantity of this heat becomes latent, and is lost for the different conditions, the quality and quantity of the resulting gases are constantly changing. To expel the gases contained in the fuel no atmospheric air is required, but only heat, while for the conversion (combustion) of the remaining solid parts (coke) into carbonic oxide atmospheric air is essential. It requires no heat, but, on the contrary, throws heat off, which is partly employed for expelling the gases from the fuel; and having thus become latent, it cannot be utilized in the combustion chamber.

With all firing arrangements in which high temperatures is the object, it is of importance not to lose heat by radiation or conduction, or to allow any of the heat to become latent. This is the case in Gröbe's generator. The gases contained in the coal are expelled in one chamber, A, and the solid remains (coke) are converted in another, B, and both gases so produced are burned in the combustion chamber, which is not visible on the perspective sketch.

A is heated by the gases after they leave the furnace (by waste heat), and the expelled hydrocarbons leave the chamber, A, highly heated. In the second part, B, the conversion of the remaining solid parts takes place, all the heat that is set free being utilized in the furnace. The generator consists of one, two, or more horizontal chambers, made of fireproof materials placed below, above, or by the side of

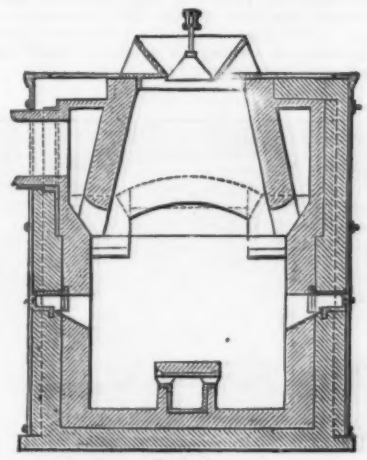


FIG. 4.

the furnace in which the gases are utilized (such as puddling, reheating, zinc, glass, and other furnaces). The chamber, A, is closed at one end by a mechanical feeding arrangement, while its other end is open and communicates with B. The feeding of coal into A can be done by hand or by machinery, and requires very little power.

The atmospheric air necessary for burning the gases arrives highly heated by previously passing through channels heated by waste heat, its access being regulated by valves. The waste heat, after passing through D, D, round A, to expel the gases from the fuel and heating the resulting coke to a bright red heat, may then be used under boilers, etc.

It has been shown by Rankine that carbon during its oxidation does not produce 14,500 British units, but 20,200, and that 5,700 of these become latent in converting the solid carbon into gas, so that only 14,500 British units are perceptible. The same rule applies to the expulsion of gases and the conversion of coal. I do not know how many units are required to convert the solid carbon, hydrogen, etc., contained in all coal into gas; but as one-third of the weight of coal must be expelled in the form of gases, and, as already mentioned, 5,700 units are required for one part of carbon, the conclusion is warranted that during the process of expelling the gases at least one-third, or 1,900 units, remain latent.

Now, if in the ordinary arrangement of generators, 14,500 are perceptible, the 1,900 units being made latent before the combustion chamber, these 1,900 units are made use of in the combustion chamber with the Gröbe generator, as they are consumed only after the gases have left the same. The great advantages which the thus increased supply of heat in the combustion chamber produces are palpable.

As only a part of the waste heat is consumed in expelling the gases after leaving the combustion chamber, and in fact just as much as is consumed in ordinary generators or grates for this purpose before the combustion chamber, the rest of the waste heat may be utilized as hitherto for producing steam, etc.

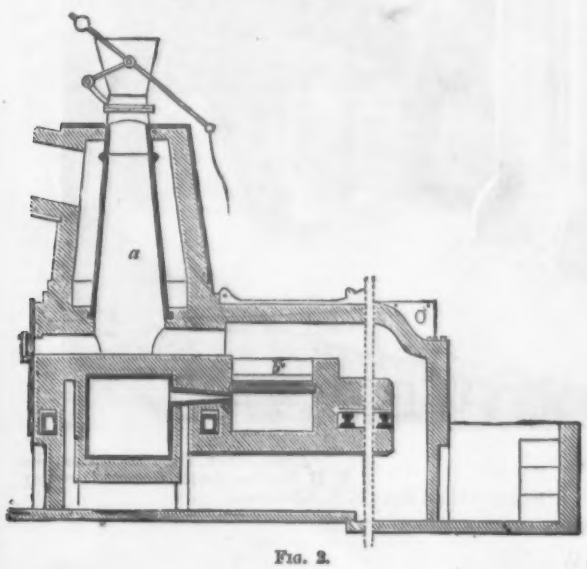
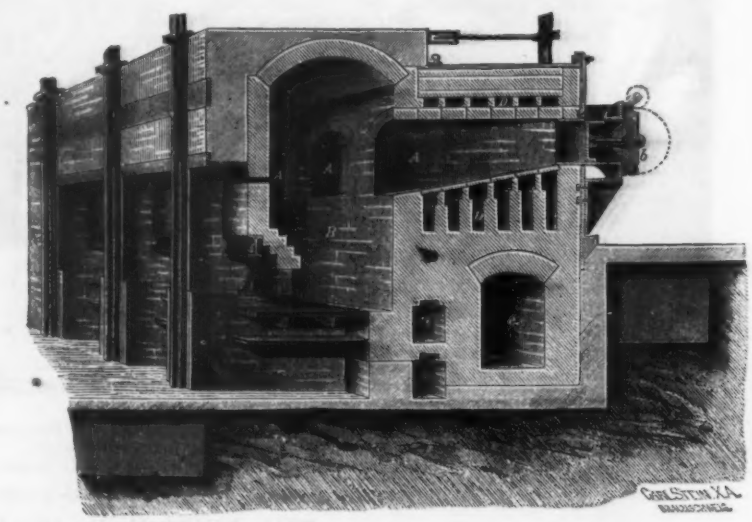


FIG. 3.



* Paper read before the Iron and Steel Institute at Düsseldorf.

Another important advantage which Gröbe's generator has over all others consists in the possibility of utilizing cheap small coal.

As the coal is here first converted into coke, not only can very small coking coal be used, but fine anthracite, which does not coke, may also be mixed with the coking coal, and consumed with advantage, as the coke leaving the expulsion chamber only requires such resistance as will enable it not to fall to dust in the conversion chamber and stop the draught. It has been proved in practice that a mixture of 50 per cent. of small but strongly coking coal with 50 per cent. anthracite dust gives coke of sufficient substance to work well. With the gases produced from this mixture the highest temperatures may be obtained.

A Gröbe's generator has been in use since the 9th December, 1879, in a reheating furnace at the iron and steel works of Osnabrück, where a surface of 6 ft. by 18 ft. is heated.

This generator is worked during the daytime only, and it consumes on an average per month of 26 turns, 122,580 kilos coal, of which 69,487 kilos or 56·65 per cent. are coking coal, and 53,141 kilos or 43·35 per cent. anthracite dust. The mixture costs per 100 kilos 0·5898 mark. This includes the coal consumed for warming during the night. The furnace is used for heating blooms of mild steel for railway sleepers, which only weigh 260 kilos each, while rail blooms weigh 580 kilos each. Nevertheless, 505,918 kilos of blooms are heated during the 26 turns. For 1,000 kilos of blooms about 242 kilos coal, costing 1·34 marks, were used, while in the Siemens generator, formerly used for the same mill, 305 kilos gas coal, costing 2·64 marks, were required. This consumption of coal per 1,000 kilos of blooms in Gröbe's as well as in Siemens' generator would of course be much less if the blooms were heavier and if the work extended over night. A steam boiler is being heated with the waste heat of Gröbe's furnace, which of course was impossible with the Siemens generator. Now, as from 2 kilos to 4 kilos of water is evaporated per kilo of coal (4 kilos directly after and 2 kilos shortly before cleaning the boiler), and estimating only 25 per cent. of the coal as being utilized in this way for producing steam, the saving in the Gröbe furnace in comparison with the Siemens furnace is further increased to at least 1·58 marks per 1,000 kilos of mild steel, or equal to 60 per cent. In consequence of these satisfactory results, the board of directors of the Osnabrück Steel Works decided to change all their Siemens generators into Gröbe generators.

The Gröbe generator has also been in use in a zinc furnace of the Vieille Montagne at Moresnet, near Aix-la-Chapelle, since December, 1879, and a second furnace for the same purpose has just been completed.

At the River Lee Iron Works, Canning Town, London, a Gröbe's generator is in use for a ball furnace, and although some trouble was experienced there at first owing to the men not being accustomed to gas heating, it now gives satisfactory results.

Gröbe generators are also in use at a furnace for plate glass at Messrs. Fourcault, Frisen & Co.'s, in Dampremy, near Charleroi, in Belgium, and one at the German spiegel glass manufactory in Freden, near Hanover; also one for concentrating copper at the Mansfeldschen Gerverschaft, in Eisleben.

A YEAR'S OPERATIONS OF THE BRITISH POST OFFICE.

THE twenty-sixth annual report on the Post Office, being that for the financial year ended the 31st of March, 1880 (during which period Lord John Manners was Postmaster-General), has just been presented to Parliament, and shows an increase of work in most departments. The number of post offices open in the United Kingdom on the 31st of March, 1880, was 912 head and 13,000 sub-offices, being an increase of 331 offices since last year; 661 new letter boxes in streets, roads, etc., have been established during the year, and the total number of receptacles of letters of all kinds is 26,753, of which number one-thirteenth are in London. The new building for the Savings Bank Department has been completed and occupied, new and large branch offices have been opened in Queen Victoria street and Fleet street, and arrangements are in progress for enlarging and improving several of the branch offices in London. New offices have been brought into use at Altrincham, Burnley, Carnarvon, Cork, Dudley, St. Helens, Walsall, and West Bromwich, and those at Blackburn, Durham, Oxford, Scarborough, and Southampton are approaching completion. The new building at Glasgow is making rapid progress. Measures are being taken to expedite the first morning delivery of letters in London and its suburbs. Additional day mails from London have been given to several towns in the north, and additional mails to London have been established from some of the remoter places on the eastern and southern coasts. Arrangements have been made with the Isle of Man Steam Packet Company for a daily mail (Sundays excepted) to the Isle of Man throughout the year, instead of during the summer only, as formerly was the case, and one or two of the smaller Orkney and Shetland Islands have now had granted to them the novel privilege of a post. A service, unique of its kind, has been established at the Clyde on a steamer plying between Greenock and Ardrishaig, in which all the ordinary work of a post office, even to the transmission of telegrams, is performed. At Liverpool the foreign plan of affixing to pillar and wall letter boxes indicators showing the public when the box was last cleared has been introduced, and will shortly also be tried in Edinburgh. On the 1st of March last the late fee charged for posting inland ordinary letters after the time of closing the boxes for the dispatch of a mail was reduced to a uniform rate of a halfpenny. Among the casualties of the year was the death of a post office guard in the Tay Bridge accident (the mail bags being nearly all recovered undamaged), and the interruption of communication with North Wales, Ireland, and even with the United States through Ireland, in consequence of the extraordinary floods in August last. On Christmas Eve the principal mails out of London were greatly delayed, and, as showing the pressure which existed, it is mentioned that the excess of ordinary letters dealt with at St. Martin's-le-Grand alone amounted to 9,000,000, and that the extra weight of registered letters was three and a half tons.

The number of inland letters dealt with in the year was 1,127,997,500, showing an increase of 2·8 per cent. on the previous year; the number of post cards was 114,458,400, showing an increase of 2·7 per cent.; the number of book packets and circulars was 213,963,000, or an increase of 8·6 per cent.; and of newspapers 130,518,400, or an increase of 0·3 per cent. Taking the correspondence of all kinds, the number was 1,586,937,000, showing an average of 46 per head of the population, and an increase of 3·3 per cent. over the previous year. The number of letters registered in the United Kingdom during the year was 8,739,191, being an increase of 21·3 per cent., and more than double the number dealt with in 1877, before the reduction of the registration fee. No fewer than 5,762,853 registered letters passed through the chief office, and 47,000 parcels containing Christmas presents were dealt with in that office as compared with 30,000 in 1878. No less than 1,417 letters containing coin and articles of value were observed which had been posted without registration, a practice which, as Mr. Fawcett points out, throws great temptation in the way of post office servants. One of such letters, which contained £200 in bank notes, was stolen in 1877, and eventually the theft was brought home to a letter-carrier, who was convicted, and £175 of the money recovered. Exclusive of postage stamps found loose to the number of 72,000, no less than 27,224 articles of various kinds escaped from their covers, and were sent to the Returned Letter Office, this number being about half as large again as in the previous year. The total number of returned letters was 5,345,678; of book packets, 3,541,103; of post cards, 496,446; and of newspapers, 374,741. Of these, 4,570,743 were returned to the writers and 78,291 reissued to corrected addresses. In 526,469 cases the writers had given no address to admit of the letters being returned to them. 21,631 letters were posted without any address, among which were 1,141 containing cash and bank notes to the amount of £433, and checks, bills, etc., for £4,251; 4,500 letters and packets were stopped on account of the objectionable nature of their contents, such as frogs, lizards, insects, etc., and in one instance a marline-spike. Following the practice pursued at London and Liverpool, the Provincial Returned Letter Offices send undelivered magazines and periodicals to local hospitals; at Glasgow they are sent to the Cumberland training ship. As regards the foreign and colonial mails, the most important points mentioned are the improved services and revision of rates of postage connected with the India and China mails, which came into operation with the new contract with the Peninsula and Oriental Steam Navigation Company on the 1st of February last; the additional mails established to Australia and the withdrawal, in deference to the wishes of the Japanese Government, of the British Post Office agencies in Japan—a step which has, however, in no way impaired the regularity and efficiency of the postal communication with this country. A few more accessions to the Postal Union have taken place during the year, and a regulation of the Postal Union, whereby the sender of a registered letter within the limits of the Union can obtain a written acknowledgment of its delivery for a fee of 2½d., has been brought into operation in this country. Packets of trade patterns between this country and France may now be sent up to a *maximum* weight of 12 oz. instead of 8 oz., and the Postmaster-General hopes before long to arrange with other foreign countries for a similar extension of the size and weight of trade patterns. The estimated number of letters, post cards, newspapers, etc., sent to European countries and to Egypt during 1879 appears from the statistical appendices to the report to be 32,941,200, or a decrease of 4·2 per cent. on the previous year. The Postmaster-General makes no attempt to account for this increase, which is the more noticeable as the estimated number received from the same countries was 32,129,400, or an increase of 12 per cent.

As regards the Telegraph Department, the number of messages received during the first six months of the year was less than in the corresponding period of the previous year, but a marked increase then showed itself, and, being more than maintained, brought up the number of messages at the close of the year to 26,547,137, as against 24,459,775 in the previous year, being an increase of 2,087,362. About 313,500,000 words of news were delivered to newspapers, clubs, etc.; 71 new offices were opened for telegraph business, the total number of postal telegraph offices in the United Kingdom being 3,924, in addition to 1,407 railway stations. Various improvements have been effected, notably in the Wheatstone receiving apparatus, and it is proposed to provide additional wires between London and many of the principal towns. The private wire business continues to increase. The revised regulations and tariffs agreed to by the International Telegraph Conference came into operation on the 1st of April last. Ten years have elapsed since the telegraphs were transferred to the State, and from the particulars given it appears that whereas the telegraph companies had at the time of the transfer 1,992 offices in addition to 496 railway offices, the Post Office can boast of 3,924 offices of its own and 1,407 railway stations open for telegraph work, or in all 5,331 offices, against 2,488 under the companies. The number of instruments in use by the companies was 2,210, by the Post Office, 8,151. In 1869 the total length of submarine cables connecting different parts of the United Kingdom was 139 miles. Last year it was 707 miles. The length of pneumatic tube employed by the companies was 4,844 yards; the Post Office now employs 48,200 yards. The total number of telegraphists employed by the companies was 2,514 (of whom 479 were women), the number of messengers, 1,471. The total number of telegraphists employed by the Post Office last year was 5,611 (of whom 1,556 were women), and of messengers, 4,648; but, besides these, many persons are employed in telegraph work who hold no appointment on the establishment, but are paid by the postmasters out of allowances for assistance. In 1869 about 6,500,000 messages were forwarded by the telegraph companies and railway companies transacting public telegraph business. Last year the Post Office forwarded 26,547,137 messages, or four times as many as in 1869.

The inland money-order business shows a falling off, but that with foreign countries and the colonies exhibits a satisfactory increase, and a reduction in the rates of commission which came into operation on the 1st of January will tend to its further development. Taking the whole business together, the total number of orders issued was 17,307,573, or a decrease on the previous year of 433,049, the amount of such orders being £26,371,020, or a decrease on the previous year of £932,073. Notwithstanding the dullness of trade and the bad harvest in 1879, the excess of deposits over withdrawals continues, and the balance due to depositors shows an increase of upward of a million and a half sterling. Of this increase no less than £91,853 falls to the share of Ireland, and of this amount the counties chiefly affected by the distress—viz., Clare, Cork, Donegal, Galway, Kerry, Mayo, Roscommon, and Sligo—contributed £25,418. The distribution of depositors in the United Kingdom was as follows: Out of the total of 1,988,477 there were 1,862,944 depositors in England and Wales, or one in fourteen of the population with an average sum of £16 2s. 4d. on each account; 53,155 in Scotland, or one in sixty-eight, with an average of £10 15s. 5d. on each account; while in Ireland there were 72,378, or one in seventy-four, with an average of £19 11s. 8d. on each account. The number of post offices at which savings bank business is transacted was increased during the year by 185, making a total for all parts of the kingdom of 6,016. During the last five years about 1,000 additional offices of this class have been established. No less than 473 penny banks were authorized to invest their moneys in the Post Office Savings Bank—a larger number than in any previous year. The branches dealing with post office annuities and life insurances show little if any expansion.

The number of officers of all grades in the service of the Post Office is 46,192, the number employed exclusively on telegraph work being 11,493. In the total of 46,192 are included 13,882 postmasters and 10,011 clerks, telegraphists, etc. The mortality among these officers is very small, but during the year the department lost by death the services of two of its principal officers—Mr. Ashurst, the solicitor, and Mr. Thomson, the controller of the Savings Bank.

An increase of £220,682 has taken place in the cost of carrying on the service, but this has been more than met by a corresponding increase in the revenue. The gross revenue for the mail service, money orders, and telegraphs combined during the year was £8,010,934, the expenditure £5,172,305, and the net revenue £2,838,629. If the value of work for other government departments be added, this last sum will attain the respectable total of £2,963,060.

Mr. Fawcett alludes to the death of Sir Rowland Hill, and also pays a graceful and well-deserved tribute to the value of the labors of Sir John Tilley, who retired during the year from the position of secretary, after a service of fifty years, and to those of Mr. Page, the late assistant secretary.—*London Times.*

AMERICAN MANUFACTURERS IN AUSTRALIA.*

IN the examination of scales exhibited the jury find as follows: Messrs. Fairbanks & Co., of New York and London, are adjudged to have exhibited the largest and most complete assortment of scales for all purposes, from heavy track scales to the delicate chemists' scales, shown at the Exhibition. We find the same uniformity of skillful manufacture in all their scales and the same sensibility of balance. The most severe tests to the qualities of the materials employed prove the uniformity and excellence of the same in every part. The variety of manufacture and modification of form and adaptability of the scales of this firm exceed all others combined exhibited, all the designs being original with the firm. They show over thirty patents for improvements made in the manufacture since the establishment of the factory. The levers being all in a direct line and free from torsion, with a simple beam combination, make them less liable to error than any scale we examined. By a new process of surface carbonization the pivots and bearings, made from the toughest Bessemer steel, are rendered hard as agate, without destroying to any appreciable extent their tensile strength, and, by scientific and practically-tested distribution of weight and strength, the scales are lighter than any other of equal capacity. The system of suspending the weighbridge platforms on swivels, with corner lockings, is specially to be commended, as there can be no unequal settling or strain upon the levers, and the transmission of the strain in a vertical line prevents any cramp of the levers. By the system of levers shown there is practically no limit to the modification of forms of platforms and adaptability to every conceivable want, of which there are already over 800 modifications now in use, including the balance and trip scales. The different parts being made by machinery and first tested to standard gauge, are all interchangeable, the beam of any ten-ton scale being equally serviceable for any other scales of the same capacity. Check-rods are used on all platform scales, the same as corner lockings upon the weighbridges, which prevents any oscillation upon the knife edges of the pivots, which must necessarily greatly increase the longevity of the scale, and preserve the sensibility of the balance. In view of the many practical advantages which this scale possesses over any and all exhibited, and as a collective exhibit, showing the perfection now arrived at by the genius of one family, your jury recommend a special distinctive diploma or medal to Messrs. Fairbanks, in addition to what would be simply a first-class award.

THE TELEPHONE CONVENTION.

THE convention of the National Telephone Association was held at the International Hotel, Niagara Falls, Sept. 7, 8, 9, and 10, and was very largely attended.

Mr. R. K. Dana, of New York, representing the Washburn & Moet Manufacturing Company, read an interesting paper on the manufacture of wire and its relation to telephonic and telegraphic transmission.

Mr. E. M. Barton, of the Western Electric Manufacturing Co. of Chicago, addressed the convention on the subject of "Cables and Subterranean Systems." He stated that Brooks' cable system consists in laying copper wires covered with cotton in an iron pipe, 1¼ inches in diameter, made tight and filled with paraffine oil under pressure. It has been tested experimentally for two or three years, and the cables laid at the earliest period are still in successful operation for telegraphic purposes. There were defects in some instances, but no cable laid during the past year has failed to work except where defects were caused by mechanical injury. The largest section in operation is from Camden to Philadelphia, in the Delaware River. The time devoted to using the Brooks cable had proved to Mr. Barton that an underground cable can be laid and operated, and at a cost not much greater than by stringing wires overhead. Other systems would doubtless be developed and rendered successful. He was convinced that cheap telephone wires could be laid and successfully maintained.

Mr. Pope stated that an ordinary Bishop telephone cable had been laid in the North River for a distance of five hundred feet, but it was difficult to distinguish words of speech when the cable was in use.

Mr. Hotchkiss stated that the kerite underground, aerial and submarine cable had demonstrated its indestructibility for twenty years.

Mr. Sargent reported that six hundred feet of a modification of the Brooks aerial cable, having over eighty wires, forty-two of which were working wires, was used successfully by his department in Philadelphia.

Mr. Haskins, of Milwaukee, stated that they were using the gas-pipe cables, and had never experienced any trouble with them.

Mr. Madden reported that the Bell Telephone Company had purchased the right of the owner of patent for the use of gutta percha cables both for itself and its licensees.

Mr. Durant said kerite could be used with impunity as against the Colgate patent.

* From the Report of Judges at the Sydney International Exhibition, 1879-1880.

Mr. Pope said that the average life of cables, according to statistics, is four years.

Mr. Fay, of Chicago, presented a long table of statistics, showing the extent of the plant and the cost of operating the Bell telephone exchange at that city. The Chicago exchange has 344 miles of trunk wires, 1,052 miles of exchange wires, 273 miles of private wires, a total of 1,066 miles. There are 1,633 telephone stations actually connected, 9 exchanges or central offices in different parts of the city, having a capacity of 2,334 wires. The exchanges make an average of 7,494 connections or conversations per day, which require, including trunk line connections, an average of 12,500 switches per day. During the first six months of 1880, 1,429,406 of these switches were made by the Chicago exchange. The cost of making these connections at Chicago for the six months was 4·6 cents a piece. This result was not considered satisfactory by the delegates, who thought that such a business was not likely to be profitable.

The following permanent officers were elected: President, George L. Phillips, Dayton, O.; Vice-President, H. H. Eldred, St. Louis; Secretary, Morris F. Tyler, New Haven, Conn.; Treasurer, D. I. Carson, New York; Executive Committee, F. G. Beach, Chicago; W. H. Eckert, Cincinnati; George L. Wiley, New York; C. N. Fay, Chicago; Advisory Committee, C. S. Beardsley, New York, three years; George C. Maynard, Washington; Noah Hodge, Youngstown, O.

The convention adjourned on Friday morning, September 10. At 2 o'clock on the afternoon of that day the delegates left for Buffalo, in two special coaches placed at their disposal by Mr. John S. Bartlett, of the Erie Railway. Arriving at Buffalo, carriages were in waiting, and all were conveyed to the Buffalo Telephone Exchange, which was thoroughly inspected by the delegates. There are in this exchange 367 live wires in operation. The handsome switch board is of the Gilliland pattern, and has ten tables. Mr. E. J. Hall, Jr., is manager of the exchange, Mr. Walton Smith chief operator, and Mr. F. M. Moore electrician. Ten female operators are employed during the day and five boys at night. There is room in the office for nine more tables, which will probably ere long be found necessary to keep pace with the constantly increasing business. The delegates also ascended to the tower, and examined the arrangement of the wires there. The tower is a model of its kind, and will well repay a visit from any telephone or telegraph man who may find himself in Buffalo. The general opinion of all present was, that the wires were run in the neatest and most complete manner of any telephone exchange in the country.

INDUCTION IN TELEPHONE LINES.

By J. W. Urquhart, C.E.

The very conditions which render the telephone superlatively adapted to the transmission and reproduction of speech also introduce the elements of that requisite sensibility to electrical influences which has so potently retarded its intromission to the business of commercial telegraphy.

FIG. 1

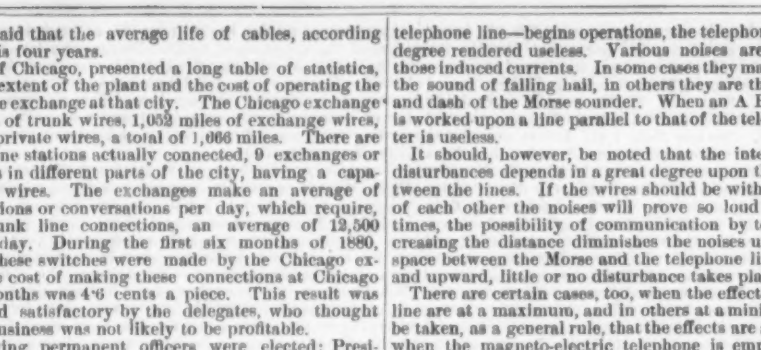


FIG. 2

Prior to the invention of the magneto-electric telephone the energies of electricians were in great part devoted to the task of introducing sensibility into our telegraphic receivers, but it was left to the labors of Bell and others to discover in the telephone, through the medium of our acoustic sense, a degree of sensibility almost incredible; and to find, at the same time, that, while the instrument was in its best working condition, it was also open to the reception of unwelcome exterior disturbances. The magneto-electric telephone of Bell, now most in use as a receiver, is actuated by the most infinitesimal electric currents or changes, and it is therefore necessarily favorable in the highest degree to the troublesome effects of induction.

It may be instructive to premise that electric induction, which by itself may appear a vague term, is based upon a fundamental law in electrical science, which expresses the peculiar tendency of a current to give rise, spontaneously, to a counter-current or currents in all neighboring and parallel inactive circuits, or in circuits containing only currents so weak that the induced currents overcome them for the time being.

In other words, if a current-bearing wire be brought near to a similar but inactive circuit, it induces a momentary current to move in the circuit. This induced current will be repeated if any one of the following changes should take place in the first circuit: (1) If the current should cease; (2) if it should return; (3) if the wire be broken; (4) if it should be again joined; (5) if the current should be reversed; (6) if the wires should be separated; (7) if the wires should be approximated.

Further, if a telephone be placed in the second circuit all those effects may be noted by noises in the instrument, and it may be readily deduced from this that in cases where the line wire of a telephone runs parallel to the lines of needle or Morse instruments, for which comparatively strong currents are employed, the induced currents will give rise to sounds loud enough to overpower the weaker tones of the received voice. At times, when the parallel wires are idle, all goes well, but as soon as one of the lines—except it be a telephone line—begins operations, the telephone is in a great degree rendered useless. Various noises are produced by those induced currents. In some cases they may be likened to the sound of falling hail, in others they are the veritable dot and dash of the Morse sounder. When an A B C instrument is worked upon a line parallel to that of the telephone the latter is useless.

It should, however, be noted that the intensity of those disturbances depends in a great degree upon the distance between the lines. If the wires should be within nine inches of each other the noises will prove so loud as to stop, at times, the possibility of communication by telephone. Increasing the distance diminishes the noises until, when the space between the Morse and the telephone lines is two feet and upward, little or no disturbance takes place.

There are certain cases, too, when the effects upon a given line are at a maximum, and in others at a minimum. It may be taken, as a general rule, that the effects are at a maximum when the magneto-electric telephone is employed as both transmitter and receiver, and when the line is consequently worked entirely by means of induced currents. It may further be accepted that the disturbances attain a minimum when the transmitter is of the carbon type, and when, in consequence, a constant battery current is employed. In the first supposed case it may be said that the telephonist has but *slender possession of his line*, and that it is thus open in a greater degree to the attacks of exterior induction. In the second case it may be supposed that the operator has in a high degree control over his line—that, in other words, he almost fully occupies it *to the exclusion of exterior disturbances*.

The effect of induction upon the telephone was the first drawback upon its introduction in the public service, for it proves almost useless when worked upon the ordinary post office lines, when all classes of instruments are employed. The telephone proved to be much better adapted to the wants of railway services, when special arrangements of the lines might be made on its behalf, and to service upon independent lines. The success of the telephone in the hands of the United Telephone Company is mainly due to the use of telephone lines upon special supports, and to the exclusive employment of carbon and current transmitting instruments.

Foremost among those electricians who have devoted so much skill and energy to the great question, the neutralization of induction effects in telephone lines, we find Messrs. Charles Moseley, W. F. Bottomley, and W. E. Heys, who, during a period extending over two years, have made numerous experiments and suggestions toward a satisfactory solution of this important question, and it is gratifying to know that their labors have now been productive of a method of arranging telephone lines which leaves little to be desired in the neutralization of induced currents, and that their method is, moreover, exceedingly simple, and can be said to be generally applicable.

The inventors record that they endeavored to overcome some part of the difficulty by localizing the primary current (carbon transmitter system) and employing a secondary current for the line. As this did not answer their expectations, they extended their experiments to a further development of the same conception, and, in doing so, used derived currents up to even a fifth circuit. This failing to answer, they continued to base their investigation upon the theory that the induced currents only existed upon the surface of the conductor. This led to the trial of a second (independent) line wire, insulated from and wound round the main line wire, with its extremities carried to earth. Much improvement was exhibited in the working of this line, into the outer wire of which the introduction of a battery current produced no effect. Many experiments were made with the idea of employing condensing plates, presumably to absorb abnormal charges, but the final outcome of the experiments is the method of arranging the line, explained further on, and which is now, we observe, protected by letters patent.

The main peculiarity of the new system lies in the invention for destroying the parallelism of the telephone circuit with Morse or needle circuits when run upon the same poles. But perhaps the more important point in the invention has reference to the plan of employing a closed circuit, or, in other words, a *metallic circuit*, throughout, without the aid of the usual earth plates. In its simplest form the system consists in running a double line wire, and employing both as one circuit. This, however, has certain other peculiarities which call for public attention. Fig. 1 will convey an idea of the theoretical conception which led the inventors to employ this method. *a b* is intended to represent a Morse or needle line, through which a circuit is supposed to be passing in the direction indicated by the arrow. *c d* is intended to represent the new system of telephone lines run upon the same poles. It will be observed that it consists of two wires, so fastened to alternate poles as to produce, on a large scale, the chain-like figure here represented. Hence, when the inductive effect of the Morse line current begins to act, it is intended to induce equal currents in *both* wires composing the telephone circuit, *c d*. The obvious result appears to be as represented by the arrows in *c d*—that is, the currents must ultimately meet and neutralize each other. But a somewhat deeper examination of the question would appear to indicate the absolute impossibility of induced currents forming in *c d*.

But passing over the theoretical aspect of the problem, it is sufficiently clear that the usual inductive effects must be considerably reduced, if not entirely eliminated.

The extremities of the circuit, *c d*, are, of coure, simply led to the telephones at either end. But, as has been indicated, it is not absolutely necessary to arrange the wires upon the poles according to the plan or elevation of Fig. 1; but there is a considerable gain in doing so, especially when the Morse line holds the relative position shown, taking *c d* as a plan or elevation at pleasure.

Fig. 2 is intended to represent the disposition of the wires upon the poles, of which *a* and *b* are examples. It will be observed that the telephone lines pass up and down upon the poles alternately, and cross each other at the center, *c*. This gives the figure already spoken of in elevation, but it is obviously a simple matter to obtain the same run of the lines as a plan, according to the situation and number of the ordinary telegraph lines, *d d*, supported upon the same pole. It is worthy of note that the inventors propose to employ a method of running the wires so as to give them a helical form—that is, one wire is caused to take a complete turn round the other every four poles passed.

In the actual carrying out of this method upon one or two lines in the Midland Counties, the inventors arrange them as follows: Starting at the upper side of one of the usual insulator arms, wire, *a*, is made fast, while wire, *b*, is attached to the under side of the same arm; at the following pole, *a* is shifted to the position of *b*, while *b* passes to the other end of the arm, underneath, as before. At the succeeding pole the same is done, and *b* is shifted to the upper side of the arm; *a* follows at the next pole; and the result is that, after four poles have been passed, a complete helical twist has been given to the pair of wires, which do not, however, come into contact at any point.

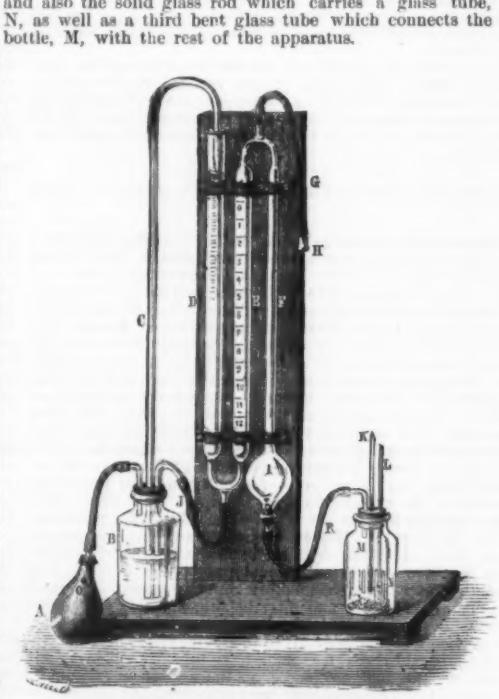
This is a very ingenious arrangement, which provides us with a circuit similar to those usually employed on very short house telephone lines—a twisted cable. The insulators upon the poles must, in this case, be numbered differently from the usual telegraphic method. A line near Manchester, nine miles long, is fitted up in the above manner, and probably furnishes the best example of a *silent* telephonic circuit extant.—*Design and Work.*

SCHEIBLER'S CALCIMETER.

Modified by H. Pellit and J. Salleron.

The different parts of Scheibler's calcimeter, modified by Pellit and Salleron, are given in our illustration.

1. First, the bottle, M, having a perforated stopper, through which passes the tube of the thermometer, K, and also the solid glass rod which carries a glass tube, N, as well as a third bent glass tube which connects the bottle, M, with the rest of the apparatus.



IMPROVED CALCIMETER.

2. A small board, to which is fastened a series of glass tubes, such as F, which being connected with the bottle, M, by means of a rubber tube, R, is furnished with a glass sphere, I, on the lower end; this tube is also connected at the upper part with the graduated glass tube, E.

3. This graduated tube, E, communicates with a third tube, D, by means of a bent glass tube which is provided with a tubulature.

4. The tubulature, to which a rubber tube is attached, serves to connect the glass tubes, E, D, with the bottle, B; the communication is made by means of a bent glass tube, the bulged end of which is inserted into the rubber tube.

5. Through the stopper of the bottle, B, passes the tube, C, and another bent tube which is connected with the rubber flask, A, the latter having an opening, O.

6. Both the bent tube having the bulge, J, and the tube, C, descend nearly to the bottom of the bottle, B, while the bent tube connected with the rubber flask, A, enters only the neck.

7. The curvature connecting the tubes, E and F, has also a tubulature which is connected with a rubber tube holding the glass bulge, G, and ending in a glass mouthpiece, H.

In order to ascertain the amount of carbonic acid contained in bone black, for example, the following method is observed:

1. Distilled water, in sufficient quantity, is poured into the bottle, B; then by pressing the thumb upon the opening, A, the water is made to ascend into the tube, D.

2. During this time the apparatus, M, is detached, and the water is made to rise simultaneously in the tube, E, till it reaches zero.

3. The end of the tube, C, must be sufficiently merged below the water to permit the rising of the latter to the

point which is marked zero in the tube, E. Thus the tube, C, acts as a siphon, and the excess of liquid returns into the bottle, B, the level at zero being automatically established. After repeated trials the custom of placing the tube, C, so that the level at zero is always secured, becomes easy. This ingenious contrivance has been already applied by Mr. G. Le Doete, in his alkalimeter.

4. After this has been done, 1·7 gr. of bone black is weighed out and put into the bottle, M, 1 or 2 c.c. of water being added for dissolving it.

5. In the tube, N, which is carried by the glass rod, L, 5 c.c. of pure hydrochloric acid are poured; after which the bottle is carefully corked and attached to the glass sphere, I.

6. At the conclusion of this manipulation, a certain pressure upon the level of the glass tube, E, will be observed. The equilibrium is re-established by compressing the rubber tube, H G, near the place of the glass bulge, G. The rubber tube may be taken between two fingers and operate so as to produce alternately a suction and a pressure which will create a passage between the glass sphere and the rubber tube. After a few efforts this detail of operation will be accomplished without difficulty.

7. By means of the right hand the whole apparatus, M, is then lifted up and slightly inclined, the hydrochloric acid falls upon the bone black, attacks it, and carbonic acid is developed. This carbonic acid remains mostly in the bottle, M, the remainder entering the sphere, I.

8. At the same time that the acid attacks the bone black, the disengaged gas presses upon the liquid in the tube, E, and the water remounts in the tube, D. The pressure of the left hand upon the rubber tube, J, near the glass bulge, where the liquid passes partially into the bottle, B, must not be suspended until the two levels are equal.

9. While the disengagement of the liquid is arrested the volume of the gas is read off from the scale, and the degrees of the thermometer, K, which denote the temperature of the bottle, M, and not that of the surrounding air, is ascertained.

10. After these figures have been obtained by means of a special table, the per cent. of carbonate of lime is found.

It is necessary to take 1·7 gr. of the finely pulverized matter to be examined, because the whole apparatus is so constructed that just this amount is necessary to indicate one per hundred part at the scale of the tube, E (at an ordinary temperature).

If the matter to be examined contains more than 25 per cent. of carbonate of lime, then the quantity of the specimen has to be diminished, and 0·85 or 0·425 are experimented with. Of course the result has then to be multiplied either by two or four.

By means of this apparatus a volumetric analysis of bone dust, meerschaum, etc., can be accomplished within one or two minutes.

MODERN SCIENTIFIC MEDICINE.

AT the meeting of the British Medical Association, held at Cambridge, England, August 10, Dr. John Buckley Bradbury, M.D., F.R.C.P., delivered the address, choosing for his subject the above.

Dr. Bradbury made it the object of his address to show what modern medicine now owed to physics and the exact sciences. These were, he said, being introduced more and more into everyday practice, and were slowly but surely tending to take away from medicine the reproach that it was not a science. He gave a brief review of the discoveries and practical uses of the various instruments of precision now employed by specialists and general practitioners. Dr. Bradbury did not make his review a complete one, but referred chiefly to those instruments which he himself employed in his own work.

By the aid of the *microscope*, an advance, he said, had been made in the diagnosis of idiopathic pernicious anæmia. By it Wilks had discovered that there was in this disease no increase in the colorless blood globules. This fact, combined with others which the microscope had first brought to light, made it possible to differentiate between anæmia, chlorosis, leucæmia, etc. The vast progress in pathology which the microscope had rendered possible was only referred to. The discovery of the disease trichinosis by Zenker, in 1860, with all its subsequent good results in the saving of human life, was due to the microscope. In view of the recent discoveries by Mr. Power of a parasite resembling trichinæ in the voluntary muscles of typhoid fever patients, the possibility that that disease is a form of trichinosis was hinted at.

The *thermometer* had done even more than the microscope to place medicine on a scientific basis. The "Treatise on Medical Thermometry," by Professor Wunderlich, has done more than any other work to further the progress of scientific medicine in the last ten years. Owing to it we are able to diagnosticate diseases which before, at an early stage, were confounded as tuberculosis and typhoid fever. We can make more confident prognoses, and use our drugs with more precision. It has led to the antipyretic treatment of fevers, which Dr. Bradbury indorsed. The special value of local thermometry was described, and M. Peter's investigations into the parietal temperatures in pleurisy were given. These show that we can tell by the thermometer whether the effused fluid is being absorbed or is increasing, and at what rate. The observations of M. Peter in cases of tuberculosis, confirmed by M. Vidal, show that as soon as tubercles occur at any point in the lung, the temperature rises there, and in doubtful cases of phthisis where the physical signs are not developed, local thermometry may assist in arriving at a correct conclusion. M. Peter's investigations in regard to the differences between the local temperatures of the abdominal parieties in ascites and in the various forms of peritonitis were also noticed. The value of temperature observations in localizing lesions of the brain were guardedly indorsed. General thermometry is useful in diagnosing cerebral hemorrhage from alcoholic poisoning; true apoplexy from the apoplectiform seizures of general paresis, disseminated sclerosis, cerebral softening, and uræmic coma.

The *ophthalmoscope* has furnished invaluable means not only of diagnosing diseases of the eye, of helping the recognition of intracranial tumors, syphilis, chronic Bright's disease, acute tuberculosis, tubercular meningitis, cerebral embolism, and locomotor ataxia. Cases of apparent brain disease, but in which the symptoms are really due to anomalies of refraction, recognizable by the microscope, also prove the value of the instrument to general medicine. Illustrations of the use of the instrument in detecting the various diseases above mentioned were given. The ophthalmoscope, Dr. Bradbury concluded, must no longer be regarded as an instrument of use only to the ophthalmic surgeon.

The *laryngoscope* had not materially extended its field during the last ten years. Dr. Marcet had, however, shown that with it laryngeal phthisis could be very early detected, even before the lungs were affected. The use of the instrument in diagnosing syphilitic laryngitis and in determining the presence, extent, and character of the membrane in diphtheria, was also a recent addition to medicine.

The *sphygmograph* was considered at great length. Dr. Bradbury believed it would prove of great service sometimes in the early diagnosis of Bright's disease. The increase of vascular tension, indicating an arterio-capillary fibrosis, might precede any structural change in the kidneys; and if detected thus early, the threatened Bright's disease might be kept off. The discovery of high arterial tension might be a help in indicating other pathological conditions and in pointing the way to successful treatment. As one of the remedies for high tension, Dr. Bradbury recommended bleeding. He expressed his confidence that bleeding was now a much neglected measure, and that it would be oftener employed in the future. Dr. Bradbury discussed the causation of albuminuria. He also spoke of the way in which Dr. Brunton, through the help of the sphygmograph, discovered the value of nitrite of amyl in angina pectoris.

The use of the *aspirator* was not dwelt upon at any great length. The speaker referred to his success with it in tapping hydatids of the liver.

The *stethometer* was also passed over briefly. It will sometimes indicate traces of lung disease that no physical examination of other kinds could display. Its chief value is in estimating the probable course of cases of phthisis and pleurisy.

The *spectroscope* is said by Dr. McMunn to enable one to distinguish blood from the bladder or urethra from blood from the kidney; and blood from the stomach from blood from the lungs.

Electricity is an agent that has helped both the diagnosis and treatment of disease. By it we are enabled to distinguish between spinal and cerebral lesions in cases of paralysis, and between peripheral and central nervous lesions.

Metallo and magneto therapy were reviewed by the speaker, who regarded the phenomena reported by Charcot and others as deserving more credence than is given by some. The theory of "expectant attention" he did not think sufficient to explain everything regarding the phenomena of transferred sensation.

TYPHOID FEVER.*

By AUSTIN FLINT, M.D., Professor of the Principles and Practice of Medicine in the Bellevue Hospital Medical College, New York.

TO-DAY I will present to you a case which I know will interest you, and I will state at the outset that it is one of typhoid fever. It may be a question whether it is not one of typho-malarial fever. Our suspicion of the existence of this is obtained principally from the previous history of the case. At the present time we are seeing cases of typhoid and of malarial fevers combined. These two fevers may be combined in a given case in varying proportions. In the present case an inference of the coexistence of these two diseases is based rather upon the history given by the friends of the patient, and also because she has been treated for some time pretty largely with quinia.

I will first of all ask your attention to the answer of this question: "On what grounds do we conclude that this patient has typhoid fever?" The patient is a young subject, twenty-seven years of age, Annie O'D——, and was admitted to Bellevue Hospital, September 7, 1880. I will confine my remarks for the present to the above question. This patient was confined with a still-birth ten weeks before her admission. She recovered from that, and, as far as we can learn, her present illness began about three weeks before she entered the hospital; she had been confined to her bed for about two weeks previous to her admission. Now this slow development of the disease is one point in favor of typhoid fever. Typhoid develops in this slow way—so slowly that the patients cannot tell exactly when they began to be sick. Usually it is from four to ten days from the beginning of the disease before the patient is obliged to take to bed. I am in the habit of calling the time when the patient takes to bed as the time when the disease begins, as the prodromic period is likely to vary considerably. This slow development of the disease is characteristic of typhoid fever; malarial fever and other fevers do not have this long prodromic period.

Since her admission she has at times manifested an inclination to cough, and, upon examination, a little bronchitis was found to exist; this also goes with typhoid fever. She complained of pain in the abdomen, and at that time her bowels appeared to be constipated. It was ascertained that she had been bleeding at the nose—epistaxis—a trifling event when taken alone, but when taken in connection with the other symptoms which are present, it is of considerable importance. Epistaxis not infrequently occurs in the early part of typhoid fever. At the time of her entrance to the hospital her temperature was found to be 103°, and on the following morning it was 104°. In the evening the temperature was the same, 104°, pulse, 100. On the next day, in the morning, her temperature was 103°. No medicinal treatment was entered upon. She was deaf, and the deafness could not be explained as being due to the administration of quinia, so we have another symptom of typhoid fever. I have known almost complete deafness to occur in typhoid fever. On the day she entered the hospital she had had two movements of the bowels. They were loose and of a yellowish color. Of course this alone would be of little or no value, but taken in connection with other symptoms which were present in her case, it is of diagnostic value. On the 9th of September her temperature was 103° in the morning. She was now placed upon half an ounce of whisky every four hours, together with milk as a diet. She has also had aromatic spirits of ammonia, which, though not a very potent remedy, is still a remedy of some value. The urine was examined, but nothing of importance was found. Upon examination of the abdomen externally it was found somewhat tympanitic, owing to the accumulation of gas in the intestines, and there was distinct tenderness in the iliac region upon the right side; this was diagnostic. We looked, of course, for the eruption, but the eruption was not present then, nor has it been present since. The absence of the eruption, however, is not very infrequent in cases of typhoid fever. The patient has been under observation since September 7, during which time there has been a typhoid condition of the mind—a passive delirium, attended with some incoherency and an indifference concerning persons and things. She has had all along the same appearance which you see now in her physiognomy. This appearance is not as marked now as it has been in the ward, owing to the excitement of the mind of a woman upon being brought into the presence of so many gentlemen; but, after all, she manifests very little disturbance.

These, then, are the points by which we may make the diagnosis of typhoid fever in the case before you; the slowness of its development, the existence and the continuance of the fever, with not much variation between the morning and evening temperatures, not so much oscillation as is found in malarial fever, the occurrence of epistaxis early in the disease, a pulse with little fluctuation, the passive delirium, the dullness of the intellect, the existence of tympanitis, the loose passages from the bowels, and the existence of bronchitis.

The husband of this patient stated that, in the house whence she came, there exists an unpleasant condition of the sewers. We have also learned that, in the same house, another individual has been attacked much in the same way and with apparently the same disease as the patient before you. So here are facts which seem to show the source of the disease to be defective sewerage. So much for the diagnosis and causation.

This patient has now been in the hospital ten days, and she was ill two weeks before she entered the hospital; that is, was confined to her bed, so by this estimate she is now in the twenty-fourth day of the disease. With regard to the duration of typhoid fever, I would say that it is a self-limited fever. It has a law of duration, yet the duration varies within tolerably wide limits. If the disease be of short duration it will last not much less than fourteen days. The longest time I have ever known it to continue is ninety days, and that was in a case in this hospital years ago. In the case before us it is evident we have not reached the end of the fever, and it is now about the twenty-fourth day.

I will now pass to another very interesting aspect of the case, and I have so much matter that I am a little embarrassed as to how to present it to you. There has been made a record of the temperature, respiration, and pulse of this patient for nearly every hour since she entered the hospital. It would be tedious to read all this, and I will, therefore, endeavor to abstract those facts which are of especial interest in reference to treatment. The interest of these facts has relation especially to the antipyretic treatment of typhoid fever and the importance of the application of cold to the surface of the body as an antipyretic measure. The antipyretic treatment of fevers has in the last few years elicited much interest, and has apparently wrought an important change in practical medicine. Fevers may be diminished in several ways. A large dose of quinia will do it in some instances, but it cannot be relied upon. Quinia has not been employed in this instance. More reliable is cold applied in the form of the cold bath, the cold sheet, or the wet pack. The cold bath was first used, but as it is a troublesome method and frequently produces a nervous shock to the patient, it has been found, on this account, desirable to use a substitute for it. I believe we can procure the same results from the cold sheet, and by that I mean the wrapping of the body in a wet cloth and sprinkling with cold water. The wet pack, although an antipyretic measure, does not accomplish much through the agency of cold, as the action of the cold is continued only for a few minutes, the body being wrapped in a wet sheet and a thick, dry covering placed over all; the good effects obtained from the pack is through other means than by cold. There is still another way of applying cold to the surface of the body, which is of all means the easiest, viz., sponging the entire surface with cold water. If the sponging be practiced thoroughly it is quite effective. Where the circumstances will admit, you can denude the whole body and sponge it thoroughly, or where this is not admissible, you may unrobe a portion of the body, and after this another part, and so on until the entire surface has been sponged. The object, in general terms, is this: Where there exists a hyperpyrexia, that is, a temperature of 103°, or over, some method of applying cold is to be employed. The patient should be carefully watched, and perhaps given a little alcoholic stimulus. After the cold has been applied for a time the patient should be placed in bed and the temperature taken, so as to determine what effect, if any, the bath has had. The temperature of the body often falls for some time after the application of cold has been suspended. It is desirable to bring the temperature down to 101° or lower. When the temperature again rises, application of the cold is again desirable, under the theoretical view, that much of the danger is in some way dependent upon the degree of the fever, and although we do not abort the fever, we abate it. I fully believe in this, and I believe it to be a very important progress in the treatment of essential fevers and certain acute inflammations. Now let us see, this is a modern treatment, and yet it is the revival of a very old treatment. Nearly a century ago an English physician, Currie, recommended this treatment, and if you have the opportunity of reading his work I would advise you to do so, for it is a work which bears the evidence of great honesty. He claims that, in a large majority of cases, he could arrest continued fevers. He employed cold water in the form of the douche, or cold affusion. I suppose, perhaps, the apparent severity of this measure led to its becoming obsolete; but Currie anticipated what we recommend to-day. It is further interesting to note that he devised an axillary thermometer, which was bent so as to be placed under the arm; in fact, he anticipated the modern use of the thermometer as well as the use of cold in fevers.—*Medical Record.*

* From a clinical lecture delivered in the Amphitheater of Bellevue Hospital, September 17, 1880.

NEW TREATMENT FOR TYPHOID FEVER.

EVERY little while the medical profession is surprised with a new treatment for typhoid fever. But there does not seem to be any limit to the variety of ways in which our therapeutic forces can be marshaled against the disease. Dr. C. G. Rothe has recently presented a new method—the antiseptic—of treating typhoid fever.

The doctor had formerly treated his cases of this disease—with due respect to him—very badly indeed, from an American standpoint at least. He was accustomed to give hourly doses of infusion of digitalis, with aconite and tincture of iodine, until a distinct effect on the pulse was produced. Whether this effect was that of the digitalis, or of that of its antagonist, aconite, it is not stated. With these drugs he used frequent cold wrappings, quinine or salicylic acid in large doses; and if the temperature persisted above 104° he gave cold baths. Of six cases which he records, treated in this way, one died, and in the remainder convalescence was much protracted.

In nineteen subsequent cases Dr. Rothe adopted a new method, which he had hit upon accidentally. This consisted in giving a mixture of one or two parts of carbolic acid, and one of tincture of iodine, in one hundred and twenty of water. A teaspoonful of the mixture was given every hour until a noticeable effect upon the pulse and temperature was produced. With this was combined for a time, at first, infusion or tincture of digitalis, and cold wrappings frequently renewed. All the cases recovered. Dr. Rothe states that

they all came under his treatment while having high morning temperatures, and that in all alike, first the pulse and then the temperature sank within from two to seven days. The pulse frequently went below the normal, and did not rise to its former height except when the medicine was discontinued, or given less frequently, by way of experiment. The effect could not have been due to the digitalis, for this was only given for a short time at the beginning of treatment. Besides, the severe symptoms immediately reappeared if the iodine and carbolic acid were discontinued. The tongue, in the cases treated as above, never got brown and crusty; the gastric symptoms subsided very early, and a moderate appetite soon appeared.

The explanation given of the way in which the drugs produce these beneficial results is: 1st, that they act upon the vagus or the cardiac centers, thus modifying vascular activity; and 2d, that they come in contact with the diseased intestine; here they have an antiseptic effect upon its ulcers, and an antibiotic effect upon any infecting germs developing at those points.

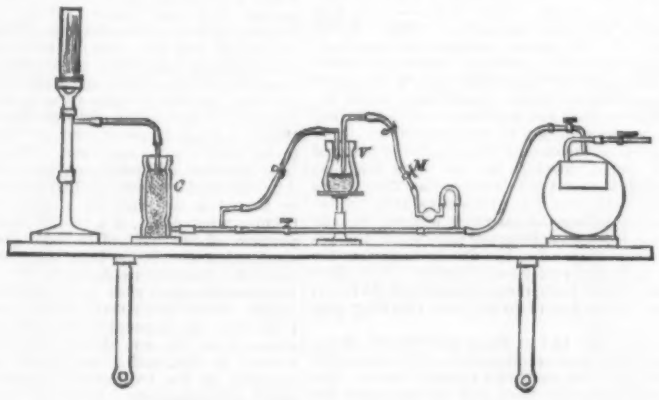
The plan of treatment thus described seems to have had extremely good results. We give it for what it is worth, and would neither advise nor discountenance its further trial. Typhoid fever is not a disease to be trifled with. At the same time it seems to be the fact that in its treatment at present one drug is about as efficient as another in modifying the course of the disease; so that we should be glad to learn if there is something really useful. We hear strong claims for turpentine, for laudanum, quinine, acids, calomel, digitalis, chlorate of potash, and baths of all kinds; there is a list of over forty "efficient and useful" drugs for the disease. All this makes one suspicious; and the fact is —a fact now widely enough understood—that if the patient is properly supplied with food and stimulants, if the temperature is kept below an excessive height, and any special symptoms met as they arise, we have done about all that can be promised just now. If there are drugs which really mitigate the course of the disease, the profession, as a body, does not recognize the fact. We should be surprised to learn that further experience proves Dr. Rothe's plan to be as efficacious as he thinks it is.—*Medical Record.*

THE RELATIVE ILLUMINATING VALUE OF THE HYDROCARBON VAPORS AND GASEOUS HYDROCARBONS PRESENT IN COAL GAS, AND THEIR QUANTITATIVE DETERMINATION.

By Mr. G. Ernest Stevenson, of Peterborough.

Dr. Knublauch, the chemist at the Cologne Gas Works, has published, from time to time, in the *Journal für Gasbeleuchtung* during the past and present years, a description of experiments made by him on the above subject, and the conclusions to which these experiments have led him.

The experiments had for their result the important discovery that equal volumes of the vapors of benzol, toluol, and other homologues of this series of hydrocarbons, give when burned in a gas burner in conjunction with coal gas, practically the same result in increase of illuminating power, and that they produce a result *six times as great* as that produced by the admixture of the same quantity by volume of hydrocarbon gases of the ethylene or olefiant series. To put it plainly, benzol and its homologues have a light-giving power equal to six times that of C_2H_4 and its homologues, or the addition of one part by volume of benzol vapor will increase the illuminating power of coal gas as much as would six parts of olefiant gas or other hydrocarbon gases of the same series. Light carbureted hydrogen, or marsh gas (CH_4), not possessing any considerable light-giving qualities except under heavy pressure, is classed along with hydrogen as a light bearer, not a light giver, and is not taken into account in these experiments. Benzol (C_6H_6) and ethylene (C_2H_4) were selected for experiment as the representatives of their series, and in order to determine the unity of each series in regard to illuminating value, toluol (C_7H_8) and ether ($C_4H_{10}O$) were also experimented upon.



The experiments were conducted in the following manner: Between the meter registering the consumption of gas and the burner of the photometer at which the illuminating power was taken, was placed a flask (V in the accompanying sketch) containing the substance (when fluid) to be mixed with the gas. The inlet pipe conducting the gas into the flask, V, terminated immediately above the surface of the liquid, the outlet pipe immediately below the cork. A straight tube having two branches at right angles to the tube itself formed a by-pass, by which the gas could be shut off from the flask, and conducted direct to the burner. This pipe was furnished with a cock, and the branches were controlled by pinch cocks on India-rubber connecting pieces in the usual manner. These, it is remarked, were made as short as possible, to avoid absorption of the benzol vapor in its passage to the burner. At C, a cylinder containing finely spun glass was introduced, for the purpose of insuring a thorough mixture of the hydrocarbon vapor with the gas.

In order to obtain a mixture of gas and vapor of sufficiently low, and also of constant illuminating power, it was found necessary to pass only a small portion of the gas over the hydrocarbon fluid in the flask, the greater part of the gas being conducted direct through the straight tube forming the by-pass. To accomplish this, a micrometer screw was fixed on the branch conducting the gas to the flask at M. The gas was consumed at the rate of 150 liters (=5·305 cubic feet) per hour. The quantity of gas passed through the flask not having been separately measured, it could not be recorded how much gas was required to absorb the necessary quantity of benzol, but the absorption was regulated so as to increase (in the case of benzol) the illuminating power of the gas from 15·7 to 17·2 candles—being an increase of 1·5 candles. To effect this, 0·827 of a gramme of benzol was absorbed and carried forward with the gas to the burner.

The experiment was performed with the other hydrocarbons in the same manner, except in the case of ethylene. Being a permanent gas, it was necessary to mix this in definite proportions with the coal gas in a gasholder immediately previous to the experiment.

To find the illuminating value of benzol as compared with the standard sperm candle is a simple rule-of-three sum. The candle burning 120 grains per hour gives a light of one-candle power. As the experiment was performed with gramme weights, it is necessary to convert the 120 grains into their equivalent in grammes=7·8 grammes. Then 0·827 : 1·5 : : 7·8 : 14·15, which is the amount of light in candles that benzol would give if it were burned at the rate of 7·8 grammes (120 grains) per hour, and in the manner employed in the experiment.

Similar experiments conducted with toluol, ethylene, and ether gave the following results as the illuminating value of each of the four hydrocarbons when burnt in conjunction with coal gas at the rate of 120 grains per hour:

7·8 grammes=120 grains... { Benzol... 14·15 candles. / Toluol.... 12·80 " / Ethylene. 7·24 " / Ether.... 2·53 "

The molecules of substances in gaseous form occupy the same space under equal conditions of temperature and pressure, therefore a molecule of benzol vapor occupies the same space as a molecule of olefiant gas. Equal volumes of different gases, then, differ in weight in the proportion of the molecular weight of their substances. The molecular weights of benzol, toluol, ethylene, and ether are as follows:

Benzol ... C_6H_6	=12×6+ 6	=78	}	These proportions by weight occupy equal space in gaseous form.
Toluol.....C_7H_8	=12×7+ 8	=92		
Ethylene..C_2H_4	=12×2+ 4	=28		
Ether ....$C_4H_{10}O$	=12×4+10+16	=74		

If we take the illuminating power developed by 7·8 grammes (120 grains) of each substance, and express the molecular weight of each substance in grammes, and suppose that weight of each substance to be consumed per hour, and then calculate the proportionate illuminating power developed by each substance under these conditions, we shall arrive at the relative light-giving value of equal volumes of the hydrocarbons under consideration:

Benzol.....C_6H_6	=78 grammes	=141·5 candles.	
Toluol.....C_7H_8	=92 "	=151	"
Ethylene ....C_2H_4	=28 "	= 25·9	"
Ether.....$C_4H_{10}O$	=74 "	= 24·1	"

—relative illuminating value of equal vols. of vapors and gases.

It will be readily perceived that very little difference exists, comparatively, between the resultants for benzol and toluol, and again a still slighter difference between those for ethylene and ether. When it is considered how very slight errors in the experiments may have multiplied in working out the results, the value of the four hydrocarbons thus expressed may be well taken to represent multiples of 24. If instead of 141·5, 151, 25·9, 24·1, we substitute the figures 144, 144, 24, 24, we find that the value of benzol and toluol is the same for equal volumes, and that it is six times as great as that of C_2H_4 and $C_4H_{10}O$, which have also an equal illuminating value the one with the other.

That this is in accordance with and bears out the theory of illumination, may be shown in the following manner: Inasmuch as the light given out by the combustion of a carbon-containing substance results from the carbon which is set free and becomes incandescent, it follows that, given equal conditions of combustion, the quantity of carbon set free is proportionate to the light produced. Thus, out of a molecule of C_6H_6, there would be six times as much carbon set free as out of a molecule of C_2H_4.

The following table shows the relative proportions of carbon contained, and the quantity set free in combustion, in the case of each of the four hydrocarbons in question, and also the illuminating value of one molecule expressed in grammes of each substance:

Symbol.	Molecule in Grammes.	Carbon contained in Molecule.	Carbon set Free.	Per Cent. of Carbon set Free.	Atoms of Carbon set Free.	Illuminating Value of One Gramme Molecule.
C_6H_6	78	72 grammes.	72 grammes.	100	6	144 candles.
C_7H_8	92	84 "	72 "	85	6	144 "
C_2H_4	28	24 "	12 "	50	1	24 "
$C_4H_{10}O$	74	48 "	12 "	25	1	24 "

If it be asked how it comes to pass that, while in the case of benzol the whole of the six atoms of carbon are set free and thus rendered available for illumination, in the case of ethylene only half, and in the case of ether only one-fourth, of the carbon is set free, the reply is, that this results from the chemical constitution of the substances. The dissociation, or splitting up of the constituent elements, must take place in accordance with the laws of chemical affinity. As compound organic substances split up into simpler groups that displace one another or hydrogen, which becomes free, so the hydrocarbons break up, under the action of heat, into simpler compounds and carbon, and as they differ in the mode of the combination of their elementary atoms, it is quite intelligible that they should differ in the mode of dissociation.

In the case of olefiant gas or ethylene there is a division into marsh gas and carbon ($CH_4 + C$). The carbon brought into incandescence *in statu nascendi* is the source of light, while the CH_4 becomes oxidized into CO_2 and H_2O. [It is true that C_2H_4, if exposed to a white heat, becomes broken up at once into hydrogen and carbon. In combustion from a burner, however, this heat is not approached.] Similar divisions take place in the first instance in the case of all combustible substances. In the case of benzol all the carbon becomes free, and contributes to the production of light.

The quantitative analysis of benzol might be indicated by the formula CH; but as the density of its vapor is thirty-nine times that of hydrogen, it is taken to consist of a group of six trivalent CH radicals. Toluol, or methyl benzol, is benzol having one of its atoms of hydrogen transplaced by an atom of the radical methyl, CH_3. Toluol may be expressed by the formula, $C_6H_5+CH_3$. This atom of CH_2 doubtless becomes immediately oxidized in the flame, and so the atom of C is lost as far as illumination is concerned. As all the homologues of benzol are formed by the substitution of some alcoholic radical for one atom of hydrogen, and each has only six atoms of carbon which belong to the benzol group, the probability is that all of them will give the same result, approximately, as benzol.

The experiments showed that in the case of ether ($C_4H_{10}O$) only one of the four atoms of carbon was set free and made available for illumination. If we consider the elementary radicals out of which $C_4H_{10}O$ is constituted, and write its formula thus: $CH_3+CH_2+O+CH_2+CH_3$, we we see that there are two methyl radicals (CH_3) and two ethyl radicals (CH_2). Very likely, therefore, only the two radicals CH_2 form the sources of free carbon, and are equivalent to one molecule of ethylene; thus: $\left\{\begin{matrix}CH_2\\CH_2\end{matrix}\right\}C_2H_4$, out of which one atom of carbon is set free, whereas the two methyl radicals are oxidized directly, and do not contribute to the illumination.

Dr. Knublauch goes on to show how the proportionate volumes of hydrocarbon vapors and gaseous hydrocarbons may be determined when the percentage of the total hydrocarbons present in coal gas has been found by absorption. On referring to the table giving the molecular weight of the four hydrocarbons expressed in grammes, the quantity of carbon set free, and the illuminating power developed, it will be seen that the weight of the carbon bears in each case the proportion of 1 to 2 to the light produced in candles. For the development, therefore, of x illuminating power there must be carbon set free at the rate $\frac{x}{2}$ grammes per hour. To follow out the experimenter's calculations in gramme weights, and with a consumption of 170 liters per hour, would, however, be useless for all purposes of comparison to those unaccustomed to deal with French weights and measures. I will, therefore, convert the grammes into grains, and apply the method pursued by Dr. Knublauch to a gas of an illuminating power of 16 candles, and a consumption of 5 cubic feet per hour.

One gramme = 15·434 grains. As, however, the rate at which the gas was consumed per hour was 150 liters = 5·305 cubic feet, we may, to counteract the excess of consumption, take 15 grains as sufficiently correct for our purpose, and translate the formula $\frac{x}{2}=C$ given above, as follows: $C=\left(\frac{x}{2}\times 15\right)$, where C = the quantity of carbon set free in grains during the period of one hour's combustion, and x the illuminating power of the gas. So, for instance, the carbon set free by the combustion of 16-candle gas is $\frac{16}{2}\times 15=120$ grains of carbon per hour.

It is worthy of remark here that as the sperm candle burns at the rate of 120 grains per hour to give a light of 1-candle power, the carbon set free by the burning of the sperm candle would, provided the conditions of the combustion were the same, be 1-16th of 120 grains = 7·5 grains. As the heat of the flame increases, so the illuminating value of the freed carbon will increase; and as the heat developed by the combustion of the sperm candle is far inferior to that of the gas at 5 feet per hour, doubtless the carbon set free bears a greater proportion to the light developed than in the case of the gas. For the same reason, the large Argand burners introduced by Mr. Sugg give a higher illuminating power per cubic foot of gas than the standard burner consuming 5 feet per hour. The 120 grains of carbon set free by the combustion of 5 cubic feet of 16-candle gas are equivalent to the consumption of 127·8 grains of benzol, supposing, for the purpose we have in view, that the whole of the carbon is obtained from the vapor of benzol present in the gas.

The specific gravity of benzol vapor is given by Dr. Knublauch as 2·604. As 100 cubic inches of air weigh 30 grains, approximately, 100 inches of benzol vapor will weigh 80·82 grains, and 127·08 grains of this vapor will equal in volume 157·13 cubic inches. This divided by 8,640, the number of cubic inches in 5 cubic feet, will give the percentage of benzol vapor by volume as 1·82. The illuminating value of benzol vapor compared with that of C_2H_4 is as 6 to 1; therefore 1·82 per cent. of the vapor of C_6H_6=10·92 per cent. of C_2H_4.

If, therefore, 1·82 per cent. of C_2H_2, or 10·92 per cent. of C_2H_4, gives to gas consumed at the rate of 5 cubic feet per hour an illuminating power of 16 candles, then 1 per cent. of C_2H_2 will produce an illuminating power of 8·796 candles, and 1 per cent. of C_2H_4 will give an illuminating power of 1·466 candles. Then

If x = volume percentage of benzol vapor,
Y = " " C_2H_4,
I = illuminating power of gas,
S = total percentage of hydrocarbons present in the gas,

we get the following equations, viz.: $8{\cdot}796x + 1{\cdot}466\,Y = I$; or (as the multiple of x is 6 to 1 of that of Y),

$$6x + Y = \frac{I}{1{\cdot}466} \quad \text{(Equation I.), and}$$

$$x + Y = S \quad \text{(Equation II.)}$$

The value of I is determined by a photometric test; that of S is found by absorption of the hydrocarbons by bromine, or, as Dr. Knublauch recommends, by the use of Nordhausen acid in a Winkler's apparatus, the SO_3 vapor being taken into the calculation. By subtracting equation II. from equation I., and dividing by 5, we get the following formula for the value of x:

$$x = \frac{1}{5}\left(\frac{I}{1{\cdot}466} - S\right) = \text{volume per cent. of hydrocarbon vapors.}$$

$Y = (S - x)$ = volume per cent. of gaseous hydrocarbons.

Therefore, to find the percentage of hydrocarbon vapors, divide the illuminating power of the gas by 1·466; deduct the total percentage of hydrocarbons present, and divide by 5. The difference between the percentage of hydrocarbon vapors so obtained and the total hydrocarbons present represents the gaseous hydrocarbons.

Apply this rule to a gas of 16-candle power, in which the hydrocarbons condensed by bromine amount to 5 per cent.:

$\frac{1}{5}\left(\frac{16}{1{\cdot}466} - 5\right) = 1{\cdot}18$ per cent. of C_2H_4 vapor, and the difference = 3·82 per cent. of C_2H_2 vapor.

The following table shows the results of this rule applied to the gas from six different analyses of coals, as given in "King's Treatise on Coal Gas:"

	Name of Coal.	Illum. Power, Five Feet per Hour.	Hydrocarbons condensed by Bromine.	Per Cent. of C_2H_2 Vapor.	Per Cent. of C_2H_4 Gases.	Illuminating Power due to Vapors.	Ill. Power due to Gaseous Hydrocarbons.
1	Pelaw Main.....	14·75	4·50	1·11	3·39	9·77	4·98
2	Wigan coal, 4-ft. seam.	14·63	3·50	1·29	2·21	11·36	3·37
3	Wigan Arley, Hindley Green.....	15·11	4	1·26	2·74	11·09	4·02
4	South Yorkshire.....	16·73	6·30	1·02	5·28	8·98	7·75
5	Real Old Silkstone....	16·75	5	1·28	3·72	11·28	5·47
6	Energlyn Llantwit ...	17·85	5·75	1·28	4·47	11·28	6·57

From this statement it will be seen how one gas may differ considerably in the proportion of its illuminating constituents from another gas of the same illuminating power. For instance, in the case of examples Nos. 4 and 5, the illuminating power is 16·73 and 16·75 candles respectively. In the case of No. 4, however, the condensed hydrocarbons = 6·30 per cent., while in the case of No. 5 they amount to 5 per cent. In the latter gas the hydrocarbon vapors in suspension amount to 26 per cent. more than in the former. Had the excess of benzol vapor been condensed out of the gas No. 5, it would have had an illuminating power of 14·45 candles instead of 16·75. We obtain thus a better insight into the actual value of a gas than if we regard the illuminating power alone.

Hitherto no importance has been attached to the percentage of hydrocarbons condensable by bromine. When this is made use of to ascertain the proportion of hydrocarbon vapors held in suspension in gas, a new interest attaches thereto. It is evident that a gas which contains a large proportion of such vapors is of less actual value than one of equal illuminating power, and containing a greater proportion of C_2H_4 and less of C_2H_2 vapor. The former contains less stable constituents than the latter, and may, by change of temperature, long continuance in the gasholder, or conveyance to a distance, become deteriorated in illuminating power to a much greater extent than would be possible in the case of the latter. Nevertheless the illuminating value of the hydrocarbon vapors is so great, compared with the gaseous hydrocarbons, that every effort should be made to retain the former in suspension in the gas.

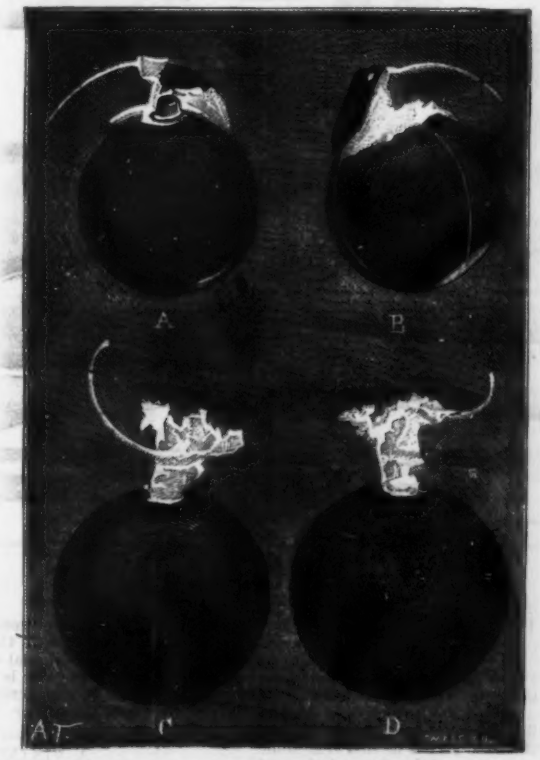
It cannot be said that the formulæ given in this paper are strictly applicable to any sort of gas. Actually they could only be correctly applied to a gas having the *light-bearing* elements, viz.: H, CH_4, and CO—in just the same proportions as the gas experimented upon; because, with a change in the constitution of the gas in this respect, a difference in the temperature at which the combustion takes place would ensue, which would alter the illuminating value of the incandescent carbon set free. Great discrepancies from this source are, however, not to be apprehended in dealing with coal gas. A greater sense of error would exist in the difference between the burners with which the illuminating power was tested. What burner was used in the experiments made by Dr. Knublauch is not stated. No doubt it was the standard burner in use at Cologne, but whether it was a No. 1 "London" Argand, or, as is more probable, a 15-hole Argand, does not appear. Provided, however, that the illuminating power of the gases to be compared be taken with the same burner, it matters little for the purposes of comparison what burner may be employed.

In conclusion, a word as to the effect of carbonization and condensation on the gas produced may not be out of place. The hydrocarbon vapors are probably given off during the early part of the process of distillation, while the gaseous hydrocarbons continue to be evolved from the charge of coal long after the vapors of C_6H_6, etc., have passed away to the condenser. If, therefore, the charging of the retorts be not divided up so as to effect a continuous evolution of an equal quantity of gas, it would follow that at one period of time gas would be passing away rich in hydrocarbon vapors, in which case very much of these vapors is likely to be deposited during the process of condensation, which might have been retained in suspension had there been a larger quantity of gas of a poorer quality traveling along with the rich gas to dilute it, and assist in absorbing the vapors. So far as possible, the condensation of gas should be conducted with a view to retain the hydrocarbon vapors, but in all probability from 1·30 to 1·40 per cent. is the utmost proportion of C_2H_4 vapor that coal gas will permanently hold in suspension. A sample of Leshmahagow cannel gas, which possessed an illuminating power of 34 candles, and in which the hydrocarbons condensable by bromine amounted to 17 per cent., gives on application of the formula $x = \frac{1}{5}\left(\frac{I}{1{\cdot}466} - 8\right)$, a percentage of 1·34 of hydrocarbon vapors, while the remaining 15·66 are gaseous hydrocarbons of the C_2H_4 series.—*Journal of Gas Lighting.*

EXPLOSIONS BY FREEZING.

DURING the severe winter of 1879-80, says Prof. Hagenbach, in *La Nature*, I performed the well-known experiment of bursting a vessel by freezing the water that it contained. In this experiment I had an opportunity of observing some accessory phenomena that I desire to describe in this place, because they are of more general interest, and throw a certain light on this mode of explosion. My operations were with spherical cast iron bombshells, having an external diameter of fifteen centimeters, an internal volume of eight hundred and eighty cubic centimeters, an internal diameter of 12·8 centimeters, and a consequent thickness of 2·2 centimeters. These shells were filled with water, closed with an iron screw plug, and exposed to the cold. The first experiment was performed Dec. 10, 1879. The shell was placed in the open air at one o'clock in the afternoon. The temperature at that time was —12° C.; at nine o'clock at night it was —18·4°, and at seven o'clock the next morning it was —14·6°. At nine o'clock at night no effect was as yet remarked, but at seven o'clock on the following morning the shell had burst in pieces. The aspect which it then exhibited is shown in Figures A and B of the accompanying cut, and which are an exact reproduction of photographs of the objects. Figure A represents the shell in its first and vertical position, and Figure B shows it as seen from the other side and in an inclined position. The second experiment was performed on the 20th of January, when another period of cold came on. The shell, prepared in the same way, was placed in the open air along about ten o'clock in the morning. At seven o'clock in the morning the temperature was —20° C.; at one o'clock —12·8°, and at nine o'clock at night —14·2°. At seven o'clock at night no effect was as yet visible, but at nine o'clock the shell had exploded, and exhibited the appearance shown in Figures C and D, which are views taken from two different sides. Although no photograph could be obtained till early the next morning, yet the modification that had taken place in the interval was insignificant, and consisted only in a slight elongation of the cylinder of ice. The first remarkable peculiarity that is exhibited by the masses of ice thus expelled is that of the thin filaments, one of which (that of December) curves downward, while the other (that of January) bends upward. These filaments have exactly the appearance of jets of water that have been suddenly frozen, and hereafter I will in fact designate them thus. On close examination they show, in addition to their curves in opposite directions, still other differences. The December jet is flat at its point of departure (it may be clearly seen in Figure B), and round further on. It exhibits equidistant expansions or nodes, and of these I counted sixteen, which were about seven millimeters apart. The January jet, like that of December, gradually decreased in size toward its extremity, being nine millimeters in diameter at its base, but no more than three millimetres at its extremity. Besides this, it showed a very marked flattening at its upper part, that is, on its concave side; and its section was nearly a semicircle. It had no protuberances.

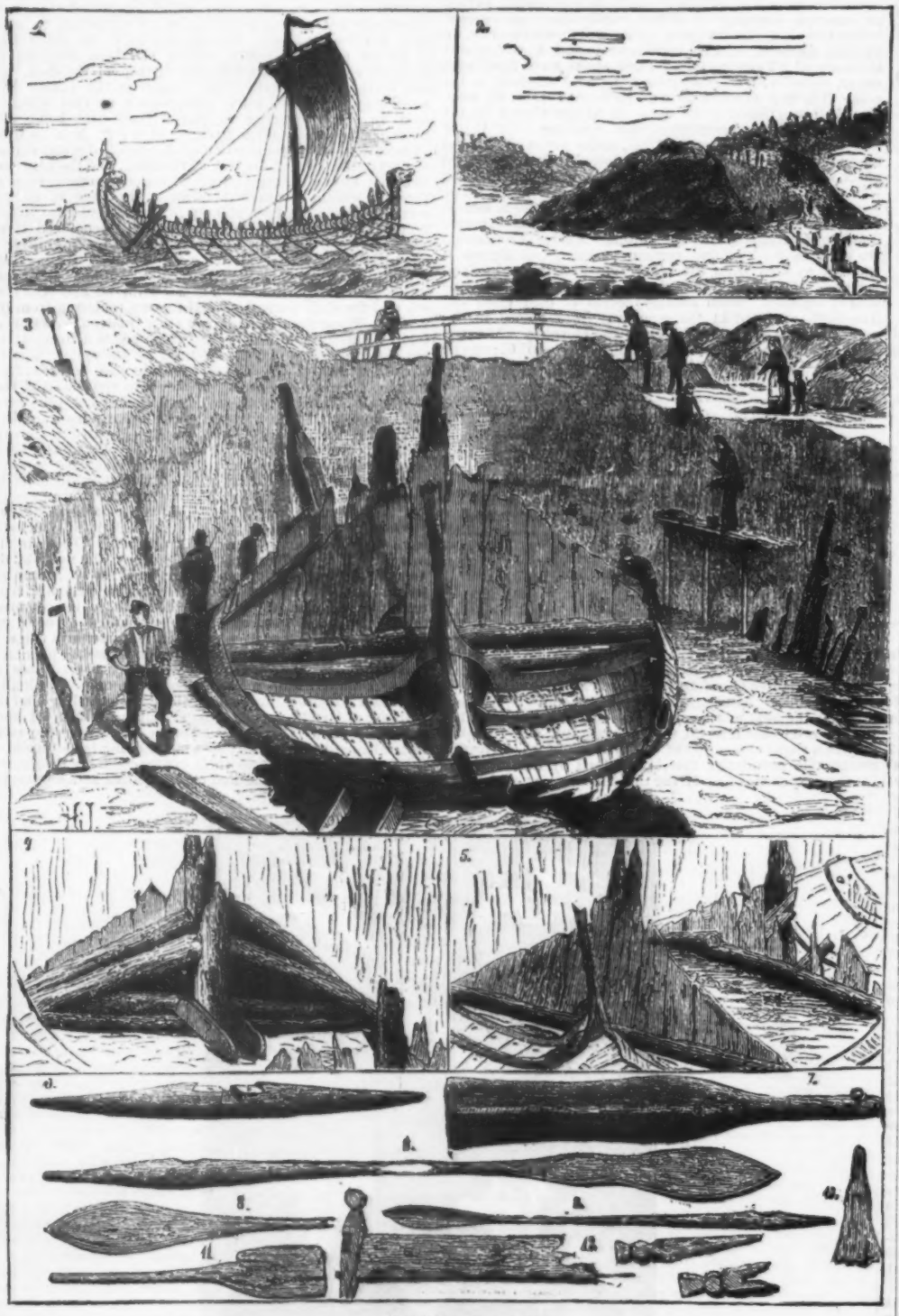
We will now try to account for the formation of these ice figures, and will begin with the one obtained January 20th, that being the one whose gradual development we shall the better be able to trace in its different phases. As the shell had been entirely filled with water, it was impossible for expansion to take place. The ice then did not immediately form, but the water became chilled to below 0°, and, in this state of superfusion, exercised great pressure on its tough envelope. The latter, by virtue of its elasticity, suffered a slight expansion, and a small opening having thus been effected in the thread of the screw plug, a small quantity of water at a temperature below the freezing point was enabled to escape therefrom, flow in a delicate stream over the exterior of the shell, and fall in small quantity on the wooden chair which supported the shell. This water on issuing, being no longer submitted to pressure, necessarily froze. I recognized this by the appearance of the jet above described, which had been flattened on its lower side by contact with the surface of the shell, and also by the frozen drops that I found on the chair. In a small way, it was the same phenomenon as that which is seen in the production of glazed frost—this being also explained by the sudden freezing of water in a state of superfusion. The congelation of the expelled water caused the crystallization of the rest of the mass, and the plug was violently ejected in consequence of the enormous increase of pressure which resulted therefrom. In spite of all my searches I have not been able up to the present time to find it again; and, since I could easily have recognized it on the clean snow lying all about the place of experiment, it must have been projected to a great distance, just as happened in the experiments performed by Williams at Quebec in 1785. Some portions of the screw thread had been torn off, and the shell showed several fissures radiating from the orifice. These fissures remained open, under the action of internal pressure, so long as the water was in a frozen state, but closed up, through the elasticity of the metal, as soon as the ice melted. A cylinder of ice had been expelled through the circular opening in the shell, and the striæ that its surface exhibited proved that the solid but plastic ice had been ejected with violence. This column had raised up with it the frozen jet of water, which exhibited a concave surface beneath, where it had lain on the side of the shell. As the quantity of heat emitted by the whole mass of water is notably greater than that which is necessary to raise its temperature from about —15° to 0°, the mass of water could not have been entirely frozen at the first instant. The ejected ice cylinder, as well as the shell itself, must still have contained some water in a liquid form. Owing to the fact that the weather was very cold, it did not take the water in the cylinder long to freeze; and that caused the latter to split above into four segments which partially separated like an expanding flower bud. The curved filament formed by the frozen water jet was reversed, its point upward, presenting then its concave base uppermost (Figs. C and D). We have every reason to believe that the phenomenon just described occurred within a very short space of time—perhaps within a fraction of a second. Gradually, the water contained in the shell stopped congealing, and the cylinder of ice elongated so that at length it broke. I then cut off all the ice that issued from the ball, and, after melting, measured the quantity of water lacking in the shell. I estimated it at eighty two cubic centimeters. As the interior volume of the shell measured eight hundred and eighty-five cubic centimeters it follows that the density of the ice had been 0·91. This measurement agrees sufficiently with direct ones, considering that it is a question here of merely quite a rude experiment, and that the ice probably contained a certain quantity of air. The detailed examination that we have just made of the January experiment will now serve us in explaining that of December. In its principal features the phenomenon was the same; the differences depended on the



BOMBSHELLS SHATTERED BY THE FREEZING OF WATER.—From Photographs.

fact that the plug was more deeply embedded, and so was not blown out. As an offset, the shell burst and a triangular piece of it was lifted up (Fig. B). The initial jet of water did not this time escape from the thread of the screw, but through the first passage way produced by the cracking of the sides of the shell. As the water had only a feeble resistance to overcome at its exit, it issued forth with a greater velocity and arose in the shape of a free jet instead of flowing along the sides of the shell; and this is why it exhibited a round section and not a semicircular one. At first I took the curve that it assumed for the parabolic trajectory of a jet of water in open air, but when I had studied the progress of the phenomenon in the January experiment better, it appeared to me probable that this jet of ice, after having been sensibly straight, owing to the great velocity of its egress, had afterwards bent under the influence of its weight until it rested on the surface of the shell, and thus afterwards took the curve of the latter's exterior.

In order to explain this fact, we must take into consideration the plasticity that this jet of ice presented when, after its sudden congelation, it must still have contained some



A VIKING'S SHIP.

water, as we have seen in the other experiment. If in imagination we put back in its place the elevated piece of shell to which the jet of ice is adhering, the extremity of the latter will nearly correspond in its curve with that of the shell's surface. The smaller curve of the jet towards its point of egress is easily explained, its broader base having necessarily been less flexible than the free end. It is important to remark further that the jet has its origin at some millimeters under the upper surface of the elevated piece of shell, and which is due to the fact that the jet of water escaped only when the fragment had already been slightly raised.

There is nothing left us but to try now to explain the equidistant protuberances or nodes that the jet exhibited. I believed that I recognized therein the form of the liquid vein such as it has been described by Savart.* This explanation at first appeared quite plausible, since, as Figure B shows, the jet at its origin was flattened horizontally; but a profounder examination of the form that the jet exhibited either in nature or in the photograph, showed me that elsewhere it did not present other flattened segments alternately succeeding each other with an inclination of 90°, but that it possessed throughout all the rest of its length a rounded section, alternately broader and narrower. We have here, then, to do with periodical expansions and contractions of the jet. Perhaps this fact can be explained by the theory that the detached fragment was possessed of a vibratory motion at the time it gave way, and that this vibration was communicated to the jet of water, and produced therein these alternate projections and depressions. I do not know whether the phenomenon of a jet of ice produced in this way by instantaneous freezing has already been described, although it probably has; for it must have taken place and been observed frequently, since it occurred with me accidentally in the two experiments that I have just described. Williams has given an account of something analogous in one of his experiments, where he observed lamellæ of ice resembling gills of fish produced on the cracks in a vessel. I think that in this experiment the water above the freezing point escaped in sheet form and instantaneously congealed in that shape. In his work on heat, Cazin gives a figure of this phenomenon; but, as the original work of Williams contains no plate, the figure in question is not a direct reproduction of the phenomenon, but has perhaps only been executed from the description of the author.

* Trans. Royal Soc. Edinburgh, vol. ii., p. 22.

A VIKING'S SHIP.

The accompanying engravings, taken from the *Norsk Familjeblad*, represent scenes connected with the recent remarkable discovery of a perfect Viking's craft, which was buried in a tumulus known as King's Hill, near the village of Gogstad, in Norway. A full description is given on page 3841 of the present volume of the Scientific American Supplement, and need not be repeated here. In Fig. 1 the artist has given a representation of one of these craft as they appeared in the olden time. Fig. 2 is a view of King's Hill, showing the excavation therein. Fig. 3 represents the forward portion of the ship as far as the partition forming the royal funereal chamber. Fig. 4 shows the remains of the rear portion of the funereal chamber. Fig. 5 gives a view of the interior of the funereal chamber. Figs. 6 to 12 represent several of the objects (oars, anchor-stock, etc.) that were found in the vessel.

ANCIENT REMAINS IN A PENNSYLVANIA CAVE.

In the exploration of a cave in Crystal Hill, near Delaware Water Gap, recently, Drs. Leidy and Porter found many interesting organic remains. Among them were bones of the raccoon, skunk, weasel, beaver, squirrel, porcupine, woodchuck, fox, wild-cat, elk, deer, and bison; the shells of two or more turtles, the bones of wild turkey, and the vertebræ of snakes in large quantities. The most interesting specimens found were the head and teeth of a gigantic beaver (*Castoroides Ohioensis*) and a large peccary (*Dicotylus compressus*), neither of which have ever been found before in Pennsylvania. Besides these were bones which had been burned and split—evidently the work of the aborigines, who sought the marrow in the bones.

Indian relics were also found, among them polished bone needles and bodkins, sea shells, and fragments of quartz, which had been used as ornaments. A flint spear-head was picked up far back in the cave, embedded in the clay. How it came there is a mystery, unless some Indian, entering the cave and finding a wild beast there, attacked it, and this spear hurled at the animal, missing its aim, sped far back into the recesses and there remained until found by the scientists.

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